COESAM/PDFC-89/07

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GENERAL DESIGN MEMORANDUM

GULFPORT HARBOR

MISSISSIPPI

AD-A223 135

DESIGN MEMORANDUM NO. 1

APPENDIX D

ENVIRONMENTAL DOCUMENTATION

US Army Corps
of Engineers
Mobile District

JUNE 1989

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Volume contains copies of pertinent environmental documentation.

COESAM/PDFC-89/07

GENERAL DESIGN MEMORANDUM

GULFPORT HARBOR, MISSISSIPPI

APPENDIX D

ENVIRONMENTAL DOCUMENTATION

GULFPORT HARBOR, MISSISSIPPI
APPENDIX D
ENVIRONMENTAL DOCUMENTATION

SECTION D-1

NATIONAL PARK SERVICE LETTER

United States Department of the Interior
NATIONAL PARK SERVICE
GULF ISLANDS NATIONAL SEASHORE
1801 GULF BREEZE PARKWAY
GULF BREEZE, FLORIDA 32561

IN REPLY REFER TO:
N16 (GUIS-R)

August 1, 1988

Mr. Larry S. Bonine
District Engineer
U.S. Corps of Engineers
Mobile District
P.O. Box 2288
Mobile, AL 36628

Dear Mr. Bonine:

It is my understanding that the Mobile District is currently engaged in planning for the major improvement project of the Gulfport Ship Channel as authorized by Congress in 1986. As you are aware, Gulf Islands National Seashore has a keen interest in activities relating to navigation projects in the vicinity of Mississippi Sound. As the Federal agency mandated with protection and preservation of the natural and historic resources encompassed by Horn, Petit Bois and Ship Islands, these projects often have a direct effect upon those resources.

On three occasions in the past, the Corps of Engineers has assisted the Park Service in the preservation of Fort Massachusetts, a National Historic Register site, through beach renourishment projects on West Ship Island. As per the selected alternative of the Corps' 1979 study of erosion protection for Fort Massachusetts, renourishment of the adjacent shoreline has been accomplished at intervals of approximately four to six years in conjunction with channel maintenance projects. Present conditions and rates of shoreline erosion indicate that it is imperative that mitigation again be initiated.

It is my hope that the Corps of Engineers can incorporate beach renourishment of the shoreline adjacent to Fort Massachusetts within the project of improvement to the Gulfport channel. We formally request that this action be considered among the disposal alternatives for the materials resulting from dredging in the immediate vicinity of Ship Island Pass.

Your consideration of this matter would be greatly appreciated. Please do not hesitate to contact either myself or Carl Zimmerman of my staff (904-934-2605) in order to discuss this issue further.

Sincerely,

Jerry A. Eubanks
Superintendent

SECTION D-2

FINAL FISH AND WILDLIFE

COORDINATION ACT REPORT

United States Department of the Interior
FISH AND WILDLIFE SERVICE

P.O. Drawer 1190
Daphne, Al 36526

June 5, 1989

Mr. N.D. McClure
Chief, Planning Division
U.S. Army Corps of Engineers
P.O. Box 2288
Mobile, AL 36628

Dear Sir:

This letter regards our ongoing and future coordination efforts relative to the Gulfport thin-layer dredge material demonstration program. As you know, the Service is participating in the formulation of a monitoring plan for the thin-layer project. We have already provided planning aid letters on the initial "straw man" documents furnished to us by your staff. Once the plan has been finalized by the team members, the Service intends to submit a planning aid letter providing our views on the expected fish and wildlife impacts of the thin-layer project. Once the 3-year study has been completed the Service intends to provide a supplemental Fish and Wildlife Coordination Act Report. Our November 10, 1988, report did not address thin-layer since at that time no authorization had been given to study the thin-layer methodology. We will continue to coordinate these efforts with your staff.

Sincerely yours,

Larry E. Goldman
Field Supervisor

cc: EPA, Atlanta, GA
NMFS, Panama City, FL
MDWC, Jackson, MS
BPC, Jackson, MS
BMR, Biloxi, MS

United States Department of the Interior
FISH AND WILDLIFE SERVICE
75 SPRING STREET, S.W.
ATLANTA, GEORGIA 30303
November 10, 1988

Colonel Larry Bonine
District Engineer
U.S, Corps of Engineers
P.O, Box 2288
Mobile, Alabama 36628

Dear Colonel Bonine:

This Final Fish and Wildlife Coordination Act Report regards the proposed Gulfport Harbor Project, and assesses the impacts of two proposed project alternatives on fish and wildlife resources, We have and will continue to coordinate this study with the Corps of Engineers' Planning Division, This report is submitted under provision of the Fish and Wildlife Coordination Act (48 Stat, 401, as amended; 16 U.S.C, et seq.),

Sincerely yours,

John I, Christian
Acting Assistant Regional Director

Enclosure

FINAL FISH AND WILDLIFE COORDINATION ACT REPORT

ON

GULFPORT HARBOR PROJECT, MISSISSIPPI

Prepared by:
Fish and Wildlife Enhancement
Daphne, Alabama

U.S. FISH AND WILDLIFE SERVICE
SOUTHEASTERN REGION
ATLANTA, GEORGIA

NOVEMBER 1988

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PURPOSE, SCOPE, AND AUTHORITY

On September 23, 1965, the Committee on Public Works of the U.S. Senate adopted a resolution requesting that the Board of Engineers for Rivers and Harbors determine the advisability of modifying the existing Gulfport Harbor project channels and port facility in order to accommodate present and prospective commerce. This study considers the economic, environmental, and social impacts of the alternative plans. The project area and channels are shown on Figure 1.

Objectives for this study are derived from Gulfport Harbor's need to accommodate larger ships desiring to call at the port. The primary objective is the deepening and widening of the ship channels and the deepening of the anchorage basin. The removal of dredged material in construction is also being studied for the possibility of use for beneficial purposes.

This report has been prepared to fulfill our responsibilities under the Fish and Wildlife Coordination Act (48 Stat. 401, as amended; 16 U.S.C. 661 et seq.) and the National Environmental Policy Act (83 Stat. 852, as amended; 42 U.S.C. 4321 et seq.).

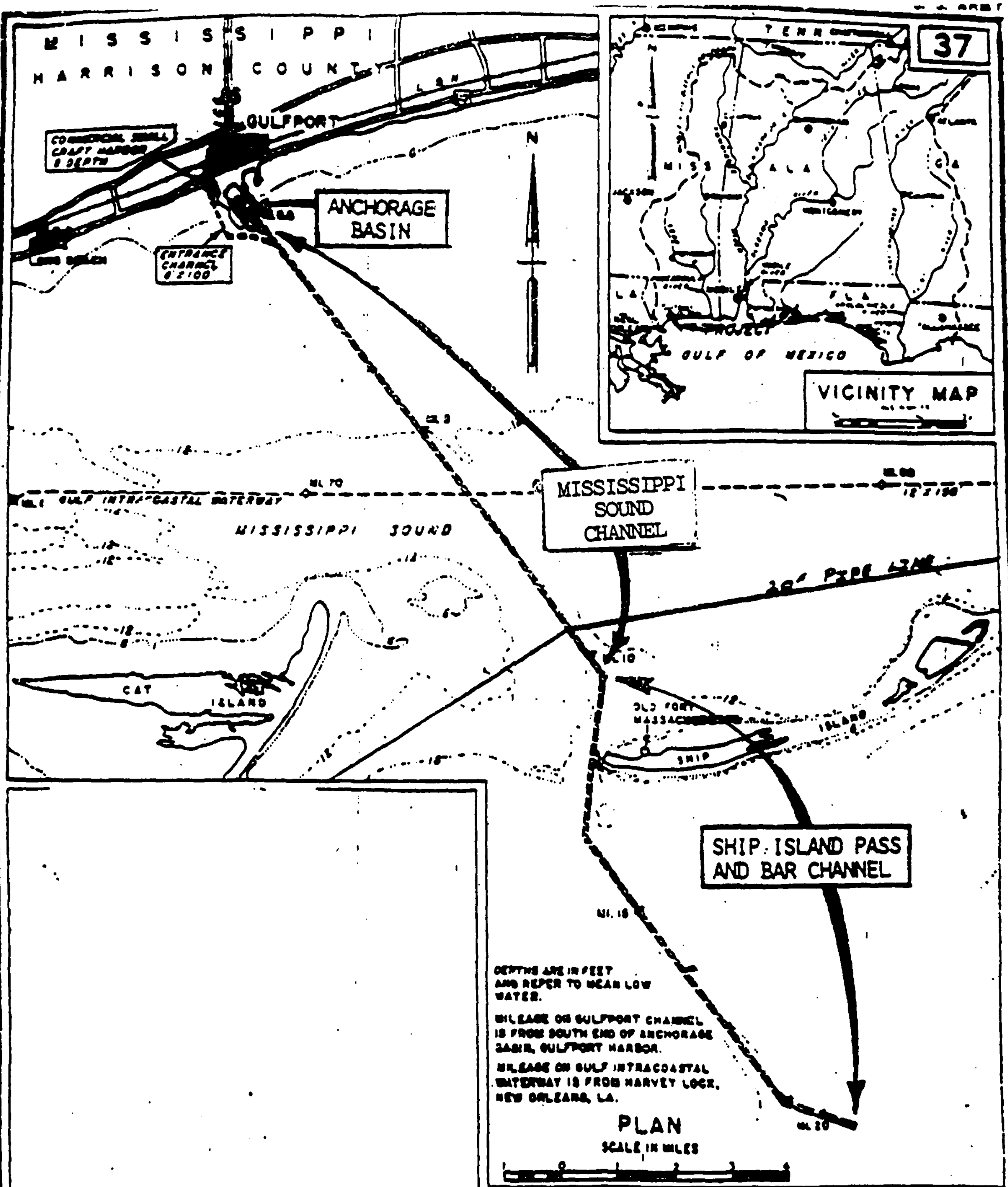
FISH AND WILDLIFE CONCERNS AND PLANNING OBJECTIVES

The Service is concerned about several specific environmental problems that exist within the project area. These are wetland losses, island (Cat and Ship) erosion, seagrass losses, oyster reef restrictions, and water quality. Each of these concerns have direct fish and wildlife implications which may be enhanced or adversely impacted by the project depending on the specific planning objectives of the selected alternative and mitigation measures.

Coastal wetlands are one of the most productive fish and wildlife habitats. Unfortunately, thousands of acres of wetlands have been lost as a result of rapid coastal development. In view of their important ecological functions, it becomes imperative that our remaining coastal wetlands be maintained. In cases where impacts are unavoidable, wetland losses should be adequately mitigated. As such the Service considers wetland preservation, creation, or management as a planning objective in terms of mitigating adverse impacts of this project.

Cat Island and Ship Island are in the project area and provide habitat for many species of fish and wildlife. The erosion and western drift of these islands is thus a concern of the Service. It is very likely that, if found feasible, dredged material may be used adjacent to the islands for some shoreline restoration stabilization measures.

Seagrasses represent one of the most productive habitats for fin and shellfish. Due to the generally turbid nature of Mississippi Sound, such grassbeds are restricted to the clearer waters on the north sides of Ship and Cat Islands. A study of the Mississippi portion of Mississippi Sound by Eleuterius in 1969 indicated that approximately 20,000 acres of submerged vegetation were present including turtle grass (<u>Thalassia</u>



GULFPORT HARBOR, MISSISSIPPI

FIGURE 1

testudinum), manatee grass (Cymodocea manatorum), shoal grass, Halodule wrightii, and widgeon grass (Ruppia maritima) (U.S. Army Corps of Engineers, 1984). However, in 1969, Hurricane Camille destroyed the majority of the submerged grassbeds (Eleuterius, L., 1973a). Recent studies by the National Park Service indicate small (less than 50 acres) patches of shoal-grass within 1,500 feet of the shoreline of East and West Ship Islands. One planning objective is to seek means of maintaining and restoring these historical seagrass beds.

Oyster reefs not only provide habitat for a highly sought commercially valuable shellfish but also provide finfish habitat as well. About 5,400 acres of live oyster reefs are located along the Mississippi Gulf Coast. Of this, about 4,000 acres are west of the ship channel and 1,400 acres in the Biloxi and Pascagoula areas. Salinity changes can have an adverse impact on oysters. High salinities (20 ppt. and higher) create ideal conditions for oyster drills (Thais haemostoma) and low salinities from high rainfall can directly cause severe mortality. We have been advised by the Mississippi Bureau of Marine Resources (MBMR) that areas are available which have salinities more suitable for oyster production. As such, the creation of oyster reefs in these areas may be pursued as a mitigation measure for project-caused impacts.

Water quality problems are not as significant at Gulfport when compared to larger port areas such as Pascagoula and Mobile. Dissolved oxygen (DO) information from this area is limited, however, spring DO concentrations between 7 and 12 ppm and summer values of 6 to 12 ppm have been reported (U.S. Army Corps of Engineers, Mobile District, 1984). From 1979 to 1982 Lytle and Lytle collected Mississippi Sound and associated bay sediments for pollutant analysis (U.S. Dept. of the Navy. EIS 1986). Their studies found total kjeldahl nitrogen values at the East Gulfport Channel to be higher than those in St. Louis Bay. This was presumed to be caused by differences in population densities and shipping activities. Fecal coliform is also of concern in Mississippi Sound where relatively high levels of contamination have been reported. In 1979, shellfish harvest was restricted due to high coliform levels. When projects involve dredging, the discharge of polluted material is always a major concern.

Based on these fish and wildlife resource concerns, our planning objectives are to coordinate with the Corps of Engineers (Corps) and other Federal and State resource agencies to select project alternatives that will 1) provide the most sound means of dredging and disposal, 2) minimize adverse impacts to fish and wildlife, and 3) adequately compensate for any unavoidable losses.

FISH AND WILDLIFE RESOURCES

Habitat Types

The major habitat types in the project area from within the Mississippi Sound to the disposal areas south of the islands include: shallow waters less than 6 ft., deep water greater than 6 ft., emergent vegetation on Ship and Cat Islands, seagrass beds on the north side of the islands, and upland habitat on each island.

Open Water

Mississippi Sound is approximately 81 miles long, 7 to 15 miles wide, and averages 9.9 ft. in depth (Eleuterius, C., 1976a). Salinities play a major factor in fauna and floral species composition within Mississippi Sound. During low river flow periods, salinities in Mississippi Sound range from 10 to 30 ppt. (U.S. Army Corps of Engineers, 1984). The salinities vary in accordance with times of the year and direction of wind (Figures 2 and 3). The average tidal range within the project area is approximately 1.5 ft. and tides are diural. Circulation within the study area is greatly influenced by the tide and winds. The bottom types within the project area consist primarily of sand (sand/silt/clay), silty clay, and silty sand (Figure 4).

Seagrasses

Submerged grassbeds within the project area are primarily on the northern sides of Ship and Cat Island. Species common to these islands are manatee grass, turtle grass, and shoal grass.

Seagrasses (Humm 1973) are also an important integral part of the estuary as illustrated by the following description of their ecological roles:

1. trap sediment and stabilize bottom sediments;

2. carry on basic productivity that, in the eastern gulf, may considerably exceed the basic productivity of all the benthic algae of the same area or of the plankton in the overlying water;

3. serve as a direct food source for marine organisms while partially decomposed leaves in the form of detritus serve as food for a wide variety of detritus-feeders, especially invertebrates and some fishes;

4. serve as a nursery for juveniles of many species of seafood organisms including shrimp, crabs, bay scallops, and fishes;

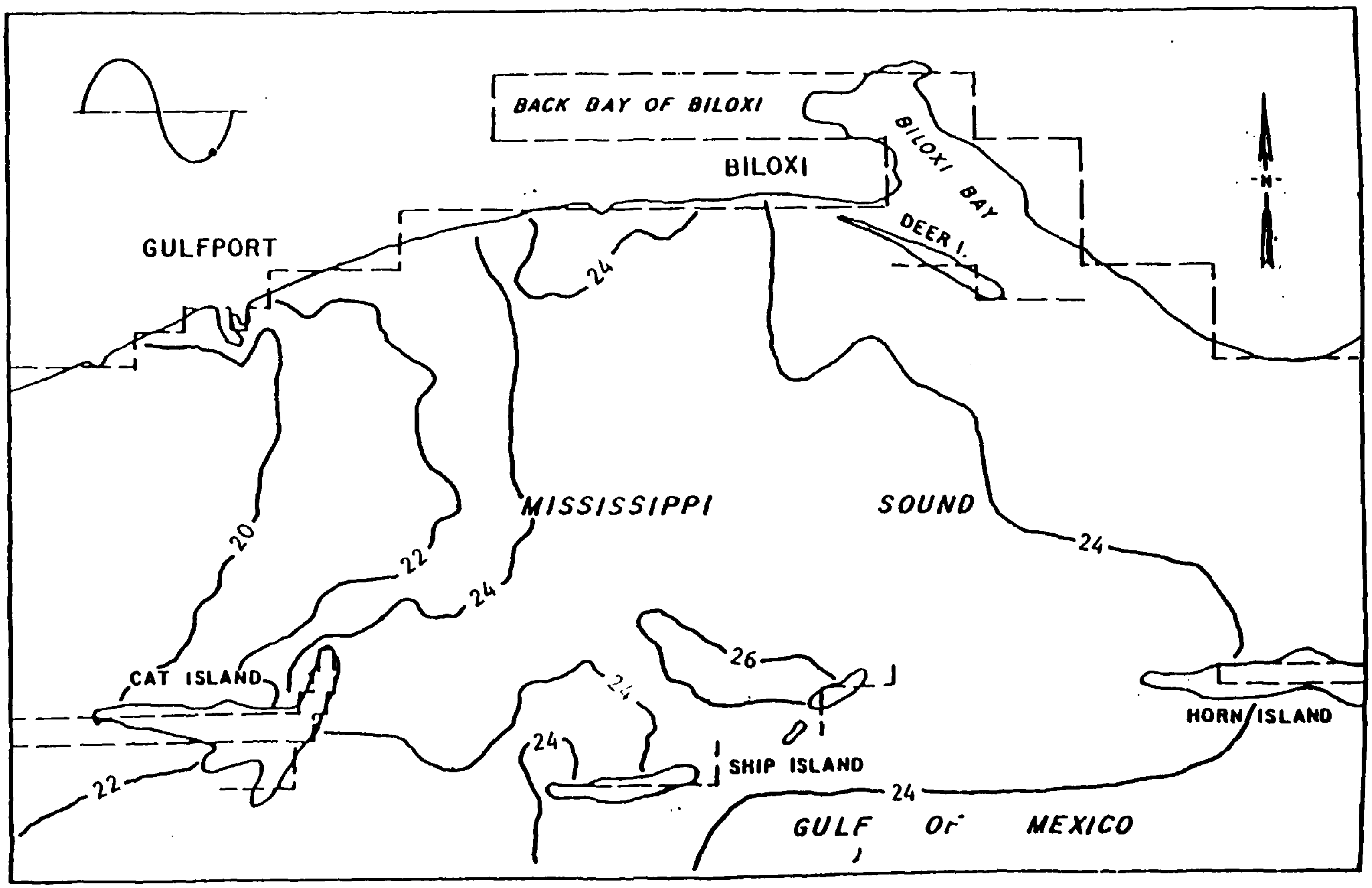
5. provide a habitat for a certain assemblage of invertebrate species that burrow or grow attached to the leaves; and

6. provide an important substrate for attachment of scores of species and a significant biomass of benthic algae.

Emergent Vegetation

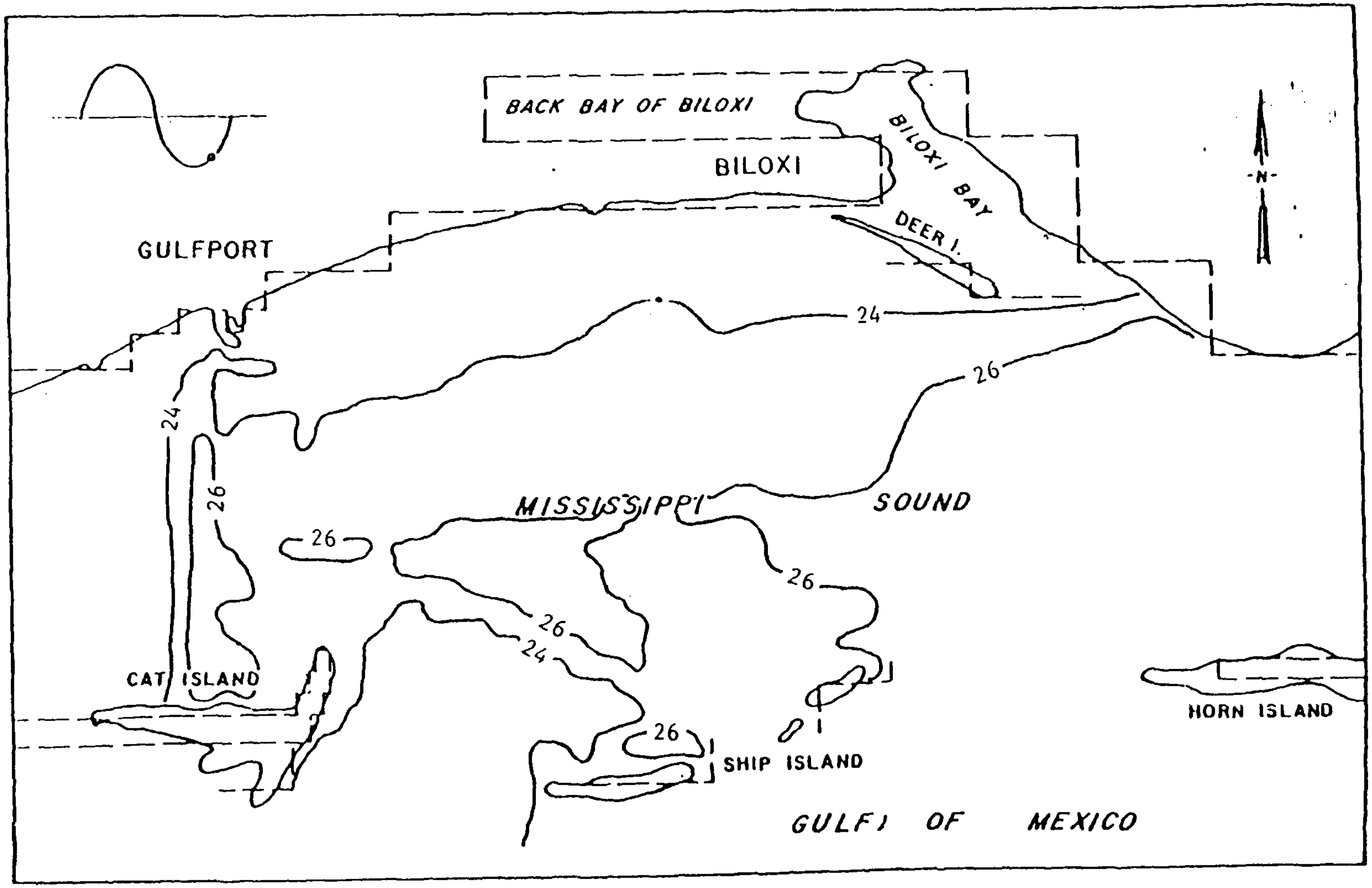
Emergent vegetation within the project area is located on Ship and Cat Islands. These marshes are represented by saline, brackish, and freshwater plant species (U.S. Army Corps of Engineers, Nov. 1976).

Saline marshes are generally dominated by black needlerush (*Juncus roemarianus*). Smooth cordgrass (*Spartina alterniflora*) is often prevalent in the intertidal zones. Other common species include saltgrass (*Distichlis spicata*) and sea lavender (*Limonium nashii*). Brackish marshes



Salinity Contours, Gulfport Channel, Base Conditions, North/Northwest Wind, Flood

Figure 2



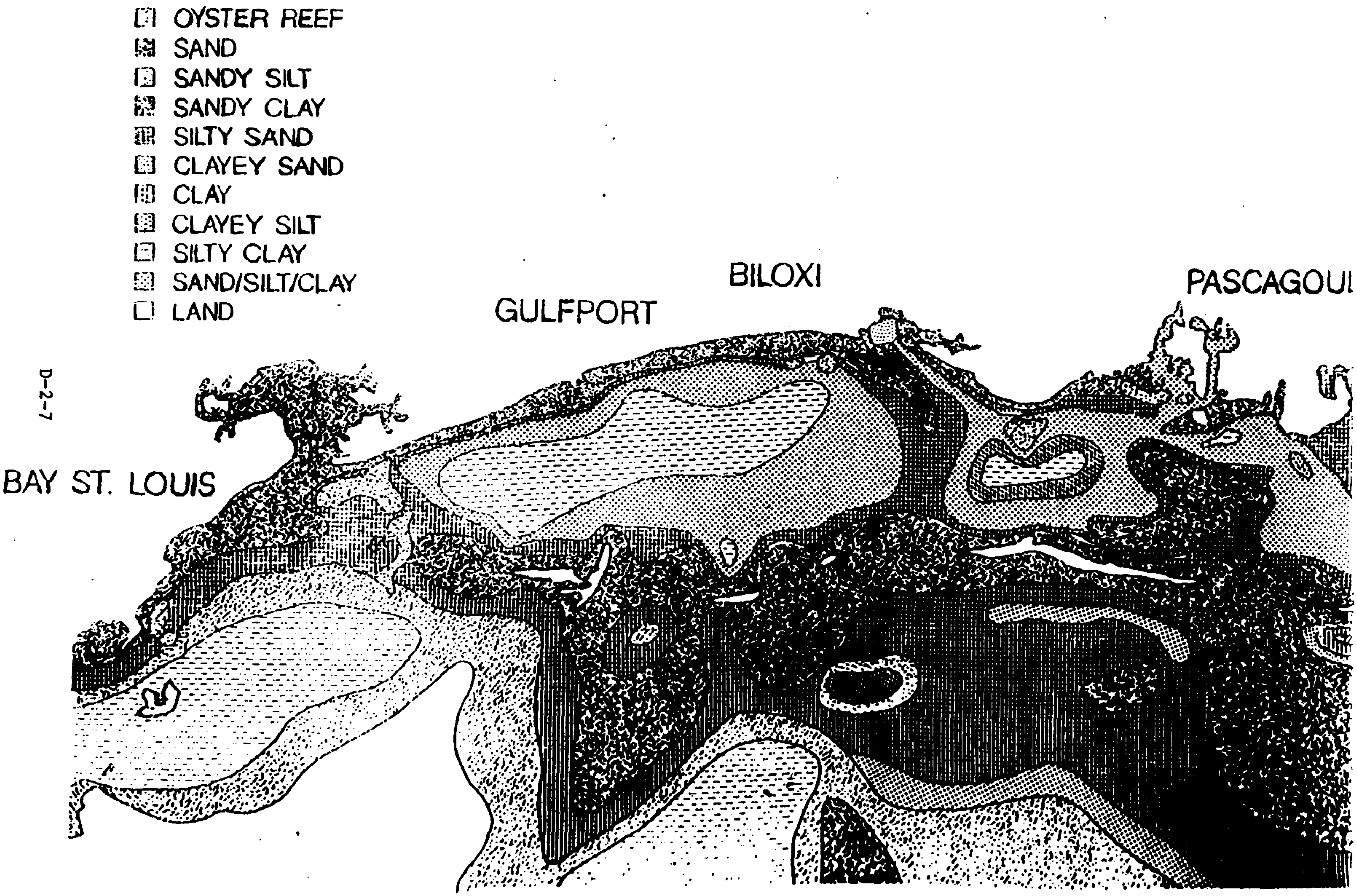
Salinity Contours, Gulfport Channel Base Condition, South/Southeast Wind, Flood

Figure 3

MISSISSIPPI SOUND AND ADJACENT AREAS STUDY

BOTTOM SEDIMENT TYPES

Figure 4



are more diverse than saline marshes and consist of species such as black needlerush, saltmeadow cordgrass (Spartina patens), big cordgrass (Spartina cynosuroides), and threesquare (Scirpus spp.). Freshwater marshes are found on the inland portions of the islands. These consist of species such as sawgrass (Cladium jamaicense), arrow-head (Sagittaria spp.), alligator weed (Alternothera philoxeroides) and cattails (Typha spp.).

Each of these wetland types support many species of fish and wildlife resources. These wetlands not only provide food and shelter for many species of aquatic and terrestrial organisms but also have the potential to assimilate pollutants from the water column.

Uplands

The higher portions of the islands support species of upland vegetation such as slash pine (Pinus elliottii), saw palmetto (Serenoa repens), and wax myrtle (Myrica cerifera). Along the islands, the land-water interface is characterized by beach conditions which support sea oats (Uniola paniculata), morning glory (Ipomoea spp.), and pennywort (Hydrocotyle bonariensis). The beaches intergrade into extensive dune conditions vegetated by saw palmetto, seaside rosemary (Ceratiola ericoides), sea oats, morning glory, and pennywort.

Fisheries

The emergent wetlands, grassbeds, and open waters within the project area interact to provide valuable habitat for many commercially and recreationally important fin and shellfishes. Other important features of this estuarine area that are vital to fishery production are the passes between the islands. Passes (Cat Island Channel, Ship Island Pass, and Dog Keys Pass) are primary routes for fishes migrating between the deeper gulf waters and the shallower estuarine waters and marshes with Mississippi Sound. Maps furnished to the Corps by the Service (National Wetlands Research Center) show fishery use of these areas by seasons. These maps are contained in the Mississippi Sound and Adjacent Areas Study.

Christmas and Waller, 1973, reported 138 fish species in 98 genera and 52 families taken from stations across Mississippi Sound. The bay anchovy (Anchoa mitchilli) were the most abundant species and made up over 70 percent of the catch. Menhaden (Brevoortia patronus), Atlantic croaker (Micropogonias undulatus), and spot (Leiostomous xanthurus) followed in order.

The life stages of most estuarine dependent fishes can be generally described. Most of these fish spawn in the open waters of the Gulf of Mexico. As the larval stages develop they are carried into the estuary by currents through the passes. As larvae reach the mouths of rivers and streams they are normally mature enough to swim into these systems for shelter and food. Once mature, they migrate out of the estuaries and back to the gulf to spawn. The value of the estuary to marine fishes is well documented. Approximately 80-90 percent of species comprising the commercial or sport fisheries depend upon the estuary for part of their life requirements.

Major commercial and sport finfishes common to this area are spotted seatrout, red drum, flounder, black drum, white trout, spanish mackerel, ladyfish, menhaden, spot, and croaker. Shellfishes within the project area also provide a highly valued sport and commercial fishery. These primarily include brown shrimp, white shrimp, blue crab, and oysters. Shrimp not only represent a very important commercial resource, but are also a major component of the food web which sustains many other commercial and sport species.

The oyster, (Crassostrea virginica), is an estuarine species which requires a bottom consisting of a good mixture of sand and mud, firm enough to support cultch material such as oyster shells or clam shells. No major oyster reefs are located within the immediate project area. They are mainly confined in an area of the Mississippi Sound between Long Beach, Mississippi, and Point St. Joe near Waveland, Mississippi. Within this reach there are about 4,000 acres of active working reefs. However, about 1,400 acres are located east of Gulfport primarily in the area of Biloxi Bay and Pascagoula Bay (MS Bureau of Marine Resources, July 1988).

Mississippi's reported commercial landings of finfish and shellfish averaged a volume of 357.8 million pounds with a dockside average value of 36.7 million dollars (1980-1983 average). Finfish and shellfish are landed in Gulfport and Pass Christian and trucked elsewhere for processing. Harrison County is the leading shellfish producing area in the state accounting for one-half or more of Mississippi landings of blue crab, shrimp, and oysters (U.S. Army, Corps of Engineers, 1986).

Wildlife

Wildlife habitat consists of the open waters of the Sound and Gulf of Mexico and the wetland and upland areas on the islands.

The open waters are utilized by mammals, birds, and reptiles. Mammals associated with open water are the Atlantic bottle-nosed dolphin and occasionally the Florida manatee. Birds utilizing the open waters include scaup, terns, gulls, pelicans, skimmers, loons, grebes, and cormorants. Sea turtles comprise the major reptilian use (see below).

Island Wildlife

Wildlife species utilizing the islands within the study area consist mainly of birds, some small mammals, and reptiles (U.S. Dept. of Interior, NPS, personal comm. 1988). Many shorebirds and wading birds frequent the islands. Park rangers report that 15 osprey nests are located on Ship Island. In addition, the island provides excellent habitat for great blue herons and yellow crown night herons. Seabirds including least terns, royal terns, sandwich terns, and black skimmers are commonly observed. Ship Island is also important for tropical migrates such as warblers, grosbeaks, and tanagers as a first landfall as they approach the United States after migrating across the Gulf of Mexico in the spring. Other birds likely utilizing Ship and Cat Islands are contained in Table 1.

Sea turtles are also known to regularly use the gulf waters near these islands. These include the loggerhead, green, Atlantic ridley, hawksbill,

Table 1

Birds occurring on or near Ship and Cat Islands

Common Loon
Red-throated Loon
Horned Grebe
Eared Grebe
Pied-billed Grebe
White Pelican
Brown Pelican
Gannet
Blue-faced Booby
Double-crested Cormorant
Magnificent Frigatebird
Great Blue Heron
Green Heron
Little Blue Heron
Cattle Egret
Reddish Egret
Great Egret
Snowy Egret
Louisiana Heron
Black-crowned Night Heron
Yellow-crowned Night Heron
Least Bittern
American Bittern
Glossy Ibis
White-faced Ibis
White Ibis
Mallard
Black Duck
Mottled Duck
Gadwall
Pintail
Green-winged Teal
Blue-winged Teal
American Wigeon
Northern Shoveler
Redhead
Ring-necked Duck
Canvasback
Greater Scaup
Lesser Scaup
Common Goldeneye
Bufflehead
Oldsquaw
White-winged Scoter
Surf Scoter
Black Scoter
Ruddy Duck
Red-breasted Merganser
Bald Eagle
Osprey
Peregrine Falcon
Merlin
American Kestrel
King Rail
Clapper Rail
Yellow Rail
Black Rail
Purple Gallinule
Common Gallinule
American Coot
American Oystercatcher
Semipalmated Plover
Piping Plover
Snowy Plover
Wilson's Plover
Killdeer
American Golden Plover
Black-bellied Plover
Ruddy Turnstone
Common Snipe
Long-billed Curlew
Whimbrel
Spotted Sandpiper
Solitary Sandpiper
Willet
Greater Yellowlegs
Lesser Yellowlegs
Red Knot
Pectoral Sandpiper
White-rumped Sandpiper
Baird's Sandpiper
Least Sandpiper
Dunlin
Short-billed Dowitcher
Long-billed Dowitcher
Stilt Sandpiper
Semipalmated Sandpiper
Western Sandpiper
Buff-breasted Sandpiper
Marbled Godwit
Sanderling
American Avocet
Black-necked Stilt
Wilson's Phalarope
Parasitic Jaeger
Herring Gull
Ring-billed Gull
Laughing Gull
Bonaparte's Gull
Gull-billed Tern
Forster's Tern
Common Tern
Sooty Tern
Least Tern
Royal Tern
Sandwich Tern
Caspian Tern
Black Tern
Black Skimmner
Belted Kingfisher
Boat-tailed Grackle

and leatherback. Of these the Atlantic ridley, hawksbill, and leatherback are listed by the Service as endangered while the loggerhead and green turtles are listed as threatened. Loggerhead turtles were reported nesting on Ship Island during the 1987 nesting season (U.S. Dept. of Interior, NPS, personal comm. 1988).

The mammal populations on the islands are limited. Mammal inhabitants of these areas include raccoon, nutria, and black rat.

Resource Categories

To assure consistent and effective recommendations on mitigating adverse effects of land and water development on fish, wildlife, and their habitats, the Service established a Mitigation Policy (Federal Register Vol. 4, No. 15, January 23, 1981). Within the policy there are four resource categories (Table 2) that are used to indicate the necessary level of mitigation.

The marine seagrass beds represent a very highly productive habitat type and one which is extremely difficult if not impossible to replace. For these reasons, we would seek a designation for marine grassbeds as a resource category I if the proposed Gulfport Harbor expansion was going to impact such habitat.

The Service has categorized the emergent wetlands within the study area as a resource category II. These coastal wetlands represent fish and wildlife habitats of extreme importance. Nationwide, wetland losses in the 20-year period after 1955 totaled 9 million acres. The average annual rate of coastal wetland losses was about 18,000 acres (Tiner, 1984).

The Service also views oyster reefs within the project area to represent a resource category II habitat. Oyster reefs are extremely vulnerable to climate conditions. Many reefs in Mississippi Sound have been altered due to storms or closed to harvest as a result of pollution. In June of 1983, the opening of Bonnet Carre spillway resulted in the mass mortality of Mississippi oyster reefs and economic losses in excess of 20 million dollars (U.S. Army Corps of Engineers, 1984). Oyster reefs not only provide a lucrative commercial fishery but also create habitat utilized for feeding purposes by many important sport and commercial fish species.

According to the Service mitigation policy, resource category II losses should be compensated for by replacing the same kind of habitat value through: 1) physical modification of replacement habitat to convert it to the same type lost; 2) restoration of previously altered habitat; 3) increased management of similar habitat so that the inkind value of the lost habitat is replaced; or 4) a combination of these measures. However, an exception can be made to this planning goal when 1) different habitats and species available for replacement are determined to be of greater value than those lost, or 2) inkind replacement is not physically or biologically attainable in the ecoregion section. In either case, replacement involving different habitat kinds might be recommended, provided that the total value of the habitat lost is recommended for replacement.

Table 2
Resource Categories for Determining
Levels of Compensation Requirements

Resource Category	Designation Criteria	Mitigation Goal
I	Habitat to be affected is of high value for evaluation species and is unique and irreplaceable on a national basis or in the ecoregion section.	No loss of existing habitat value.
II	Habitat to be affected is of high value for evaluation species and is relatively scarce or becoming scarce on a national basis or in the ecoregion section.	No net loss of inkind habitat value.
III	Habitat to be affected is of high to medium value for evaluation species and is relatively abundant on a national basis.	No net loss of habitat value while minimizing loss of inkind habitat value.
IV	Habitat is of medium to low value to evaluation species.	Minimize loss of habitat value.

The open unvegetated waterbottoms have been classified as a resource category III habitat. According to Service policy, it is preferable, in most cases, to recommend ways to replace such habitat value losses inkind. However, if the Service determines that inkind replacement is not desirable or possible, then other specific ways to achieve this planning goal include: 1) substituting different kinds of habitats, or 2) increasing management of different replacement habitats so that the value of the lost habitat is replaced. By replacing certain habitat losses with different habitats or increasing management of different habitats, populations of certain species would be different, depending on the ecological attributes of the replacement habitat. This would result in no net loss of total habitat value, but might result in significant differences in the composition of fish and wildlife populations. This is generally referred to as out-of-kind replacement.

Endangered and Threatened Species

Several species of wildlife listed by the Service and State of Mississippi as being endangered or threatened are known to occur or visit the project area (Table 3).

Sea turtles are found in the waters within the project area and specifically along the islands. In 1987 loggerhead turtles were reported nesting on Ship Island (U.S. Dept. of Interior, NPS, personal comm. 1988).

Even though Horn Island would not be directly affected by the project, it is interesting to note that a bald eagle hacking program was initiated in the winter of 1985 on the island by the National Park Service. The intent of this program is to try to reestablish bald eagle populations along the coastal regions. It will be several years before the success of this effort is known.

Even though no adverse effects on endangered species are expected, they should be given full consideration during project planning. Since some species are currently under status review and could become listed during the project construction period, we recommend that you stay informed on their status along with the presently listed species.

Coastal Barriers Resources Act

The Coastal Barriers Resources Act (CBRA) (P.L.97-348), enacted on October 18, 1982, is broad legislation resulting from Congressional concern over burgeoning Federal expenditures in coastal areas. Most concern was voiced over expenditures in coastal barrier areas which are subject to frequent drastic change from natural forces. The purpose of the Act is to minimize the loss of human life, wasteful expenditures of Federal revenues, and damage to fish, wildlife, and other natural resources associated with coastal barriers. CBRA establishes the Coastal Barrier Resources System (CBRS) consisting of a series of units along the Atlantic and Gulf coasts.

Under CBRA, no new expenditures or new financial assistance may be made available under authority of any Federal law for any purpose within the CBRS, except as provided in Section 6 of the Act. Expenditures or

Table 3
Federally Listed Species in the Project Area
(E=Endangered; T=Threatened; CH-Critical Habitat determined)

Species	General Distribution
Mammals	
Manatee, Florida (Trichechus manatus)-E	Coastal waters
Panther, Florida (Felis concolor)-E	Entire state
Whale, right (Eubalaena glacialis)-E	Coastal waters
Whale, finback (Balaenoptera physalus)-E	Coastal waters
Whale, humpback (Megaptera novaeangliae)-E	Coastal waters
Whale, sei (Balaenoptera borealis)-E	Coastal waters
Whale, sperm (Physeter catodon)-E	Coastal waters
Birds	
Eagle, bald (Haliaeetus leucocephalus)-E	Entire state
Falcon, peregrine (Falco peregrinus)-E	Entire state
Pelican, brown (Pelecanus occidentalis)-E	Coast
Warbler, Bachmann's (Vermivora bachmanii)-E	Entire state
Woodpecker, ivory-billed (Campephilus principalis)-E	South, W. Central
Woodpecker, red-cockaded (Picoides dentrocopos borealis)-E	Entire state
Reptiles	
Alligator, American (Alligator mississippiensis)-E	Coastal plain
Snake, eastern indigo (Drymarchon corais couperi)-T	South
Turtle, Kemp's (Atlantic) ridley (Lepidochelys kempii)-E	Coastal waters
Turtle, green (Chelonia mydas)-T	Coastal waters
Turtle, hawksbill (Eretmochelys imbricata)-E	Coastal waters
Turtle, leatherback (Dermochelys coriacea)-E	Coastal waters
Turtle, loggerhead (Caretta Caretta)-T	Coastal waters

financial assistance made available under authority of any Federal law shall be new if:

"(1) in any case with respect to which specific appropriations are required, no money for construction or purchase purposes was appropriated before the date of the enactment of this Act; or

(2) no legally binding commitment for the expenditure or financial assistance was made before such date of enactment."

Under Section 6, the appropriate Federal officer, after consultation with Department of the Interior, may make Federal expenditures or financial assistance available within units of the CBRS if the proposed action falls within the following exceptions:

(1) facilities necessary for energy exploration and development
(2) ship channel maintenance and dredge disposal
(3) maintenance of highways
(4) military activities essential to national defense
(5) Coast Guard facilities
(6) Activities permitted, if compatible with the purposes of the CBRA, including:

  (a) management of fish, wildlife, and their habitat
  (b) establishment of air and water navigation devices
  (c) projects under the Land and Water Conservation Act and Coastal Zone Management Act
  (d) scientific research
  (e) emergency actions related to disaster relief
  (f) maintenance of roads not a part of an essential system
  (g) non-structural projects for shoreline stabilization.

The activities can only be conducted after consultation with the Secretary of the Interior. This responsibility has been delegated to the Regional Director, Fish and Wildlife Service.

It is possible that the Gulfport Harbor project might involve provisions of CBRA because it could include actions to nourish the beaches and shallow waters adjacent to Cat Island which is a unit of the Coastal Barrier Resource System. As project plans are finalized, consultation with the Service regarding this matter may be necessary.

FISH AND WILDLIFE CONDITIONS WITHOUT THE PROJECT

It can be reasonably assumed that, without the project, erosion and westward drift of the islands would continue. To what degree this would occur is speculative since unpredictable natural forces such as tropical storms would likely play an integral role in the rate of erosion and

drift. In any event wetland, upland, and openwater habitat would be affected.

We have no basis for projecting any significant permanent changes of the open waters of Mississippi Sound or the gulf. It is, therefore, assumed for purposes of project impact analysis that the existing conditions would be more or less maintained.

PROJECT ALTERNATIVES

A survey study of the Gulfport Harbor, Mississippi, project is now being conducted by the Corps. The existing project for deep draft navigation at Gulfport Harbor provides for a channel across the Bar and Ship Island Pass that is 32 ft. deep, 300 ft. wide, and about 8 miles long; a channel through Mississippi Sound 30 ft. deep, 220 ft. wide, and about 11 miles long; and an anchorage basin at Gulfport 30 ft. deep, 1,320 ft. wide, and 2,640 ft. long (Figure 1). The amount of maintenance material dredged from each of these channels on an annual basis is Bar Channel, 325,680 cys; Ship Island Pass, 263,481 cys; and Mississippi Sound 2,650,847 cys.

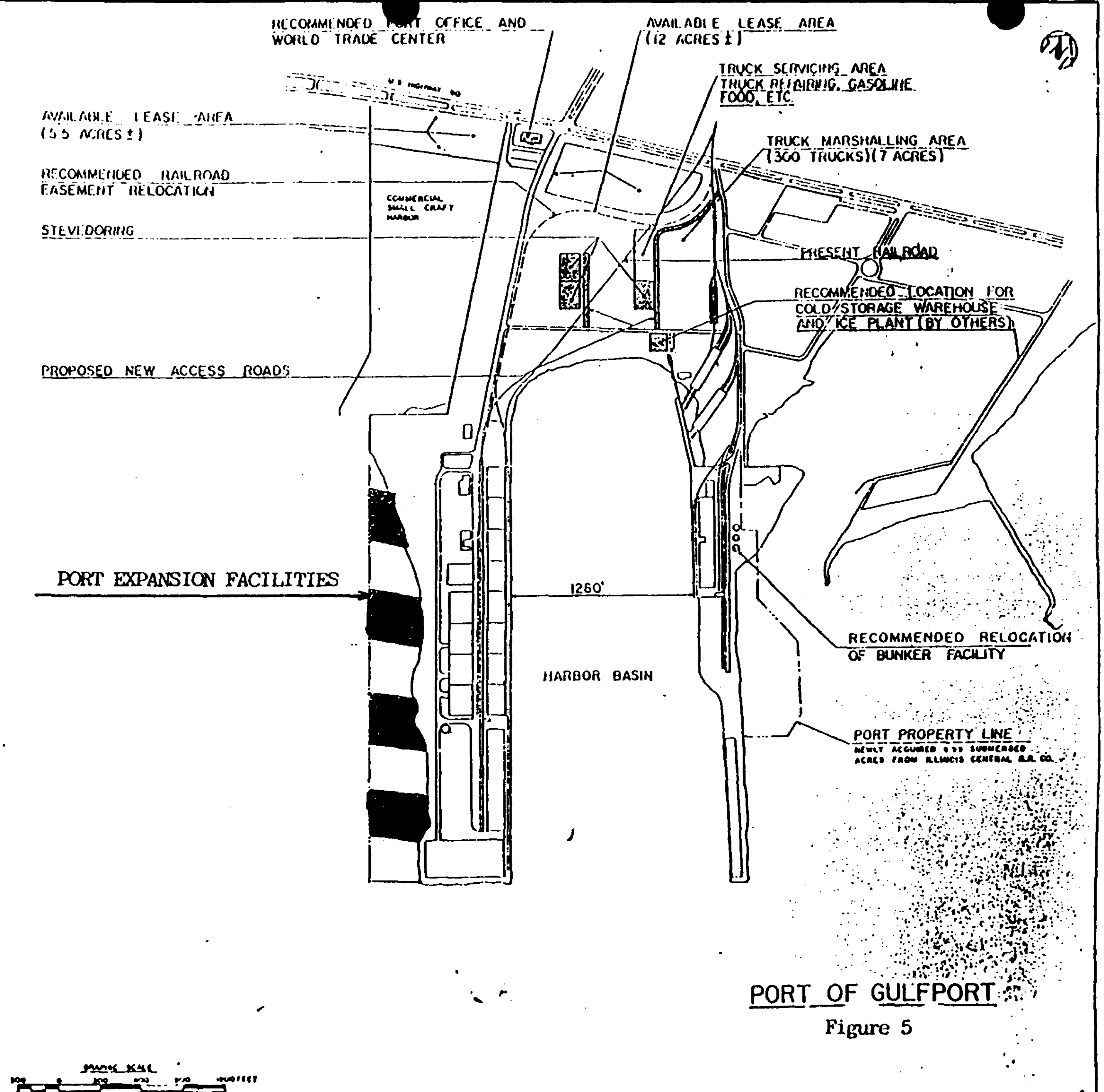
The Corps is considering two alternatives: the Authorized plan, and the National Economic Development plan (NED). With either plan the Port Authority is proposing to utilize new work material dredged from the turning basin for filling 29 acres of open water for port expansion. This fill would constitute an activity subject to provisions of Section 10 of the River and Harbor Act of 1899 and Section 404 of the Clean Water Act of 1972 (as amended) and would be administered through the permitting process of the Corps Regulatory Branch (Figure 5). Major differences in the Authorized and NED plans involve channel size and subsequent amounts of disposal material (Table 4).

Authorized Plan

The Authorized plan provides for a 36 ft. by 300 ft. channel across 11 miles of Mississippi Sound, a 38 ft. by 400 ft. channel through Ship Island Pass, and a 38 ft. by 400 ft. Bar Channel in the Gulf of Mexico that is 8 miles long. The amount of new work material that would be dredged from the Mississippi Sound, Ship Island Pass, and Bar Channels are (in cu. yds.) 11,350,200, 3,208,200, and 4,319,900 respectively. About 2.9 million cu. yds. of material would be dredged from the turning basin. Of this, about 1.5 million cu. yds. would be used for port expansion and 1.4 million cu. yds. would be taken to deep gulf sites. About 154,699 cu. yds. of material would be dredged for berthing areas.

The annual amounts (in cu. yds.) of maintenance material that would be dredged from these basins and channels are: 1) Turning Basin, 683,500; 2) Berthing areas, 60,000; 3) Mississippi Sound, 3,204,898; 4) Ship Island Pass, 1,117,988; and 5) Bar (Gulf) Channel, 755,580.

Under this plan all of the new work material, with the exception of the fill for port expansion, and maintenance material would be taken to gulf disposal sites (Figure 6). Material from the Ship Island Channel would be

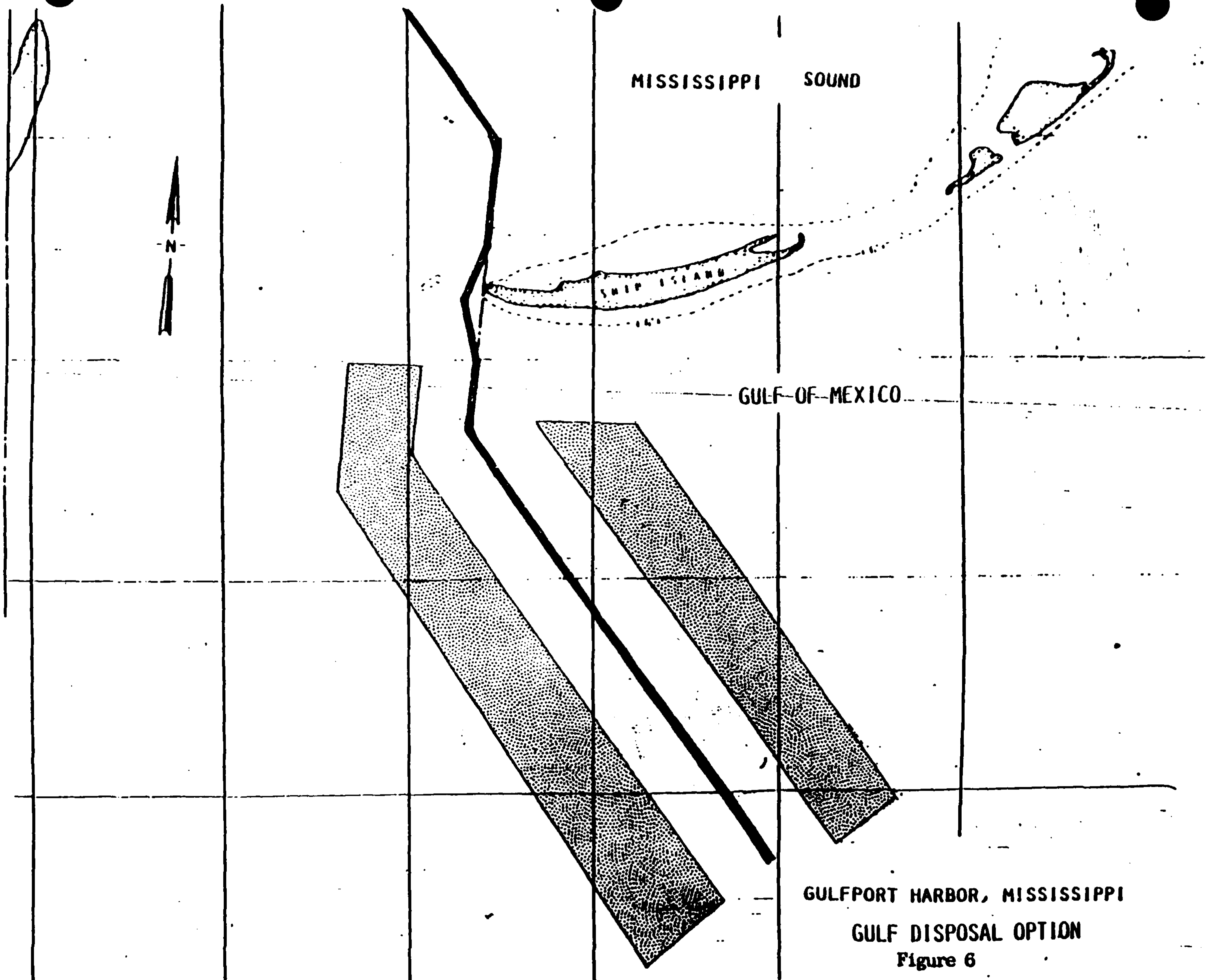


PORT OF GULFPORT

Figure 5

Table 4
Cubic Yards of Material at Various Locations in the Port And Along the Ship Channel for the Authorized and NED Plan

	NED	Authorized
Turning Basin		
New Work	2,857,114	2,857,114
New O&M	265,072	265,072
Existing O&M	418,428	418,428
Berthing Areas		
New Work	154,699	154,699
New O&M	30,000	30,000
Existing O&M	30,000	30,000
Mississippi Sound	36' x 220'	36' x 300'
New Work	7,454,100	11,350,200
New O&M	34,674	554,051
Existing O&M	2,650,847	2,650,847
Ship Island Pass	38' x 300'	38' x 400'
New Work	2,589,700	3,208,200
New O&M	190,220	295,513
Existing O&M	263,481	263,481
Bar (Gulf) Channel	38' x 300'	38' x 400'
New Work	3,052,600	4,319,900
New O&M	278,064	429,900
Existing O&M	325,680	325,680
Total New Work	16,108,213	21,890,113
Total New O&M	798,030	1,574,536
Total Existing O&M	3,688,436	3,688,436



GULFPORT HARBOR, MISSISSIPPI
GULF DISPOSAL OPTION
Figure 6

placed southeast of Cat Island in a manner for it to be incorporated into the littoral drift (Figure 7).

NED Plan

The NED plan provides for a 36 ft. by 220 ft. channel across Mississippi Sound, a 38 ft. by 300 ft. channel through Ship Island Pass and a 38 ft. by 300 ft. bar channel in the Gulf of Mexico. The amounts (in cu. yds.) of new work material that would be dredged from the Mississippi Sound, Ship Island Pass and Bar Channels are 7,454,100, 2,589,700, and 3,052,600 respectively. As with the Authorized Plan, about 2.9 million cu. yds. of material would be dredged from the turning basin. Of this, about 1.5 million cu. yds. would be used for port expansion and 1.4 million cu. yds. would be taken to deep gulf sites. About 154,699 cu. yds. of material would be dredged for berthing areas.

The amounts (in cu. yds.) of maintenance material that would be dredged annually from each of these channels and basins would be: 1) Turning Basin, 683,500; 2) Bar Channel and Berthing areas, 60,000; 3) Mississippi Sound, 2,865,521; 4) Ship Island Pass, 453,701, and 5) Bar Channel 603,744.

Under this plan, all of the new work material, with exception of the fill for port expansion, would be taken to gulf disposal sites south of Ship Island. In addition, like the authorized plan, the NED plan requires placing material dredged from the Ship Island Pass Channel on the southeast side of Cat Island in order to maintain natural littoral drift conditions.

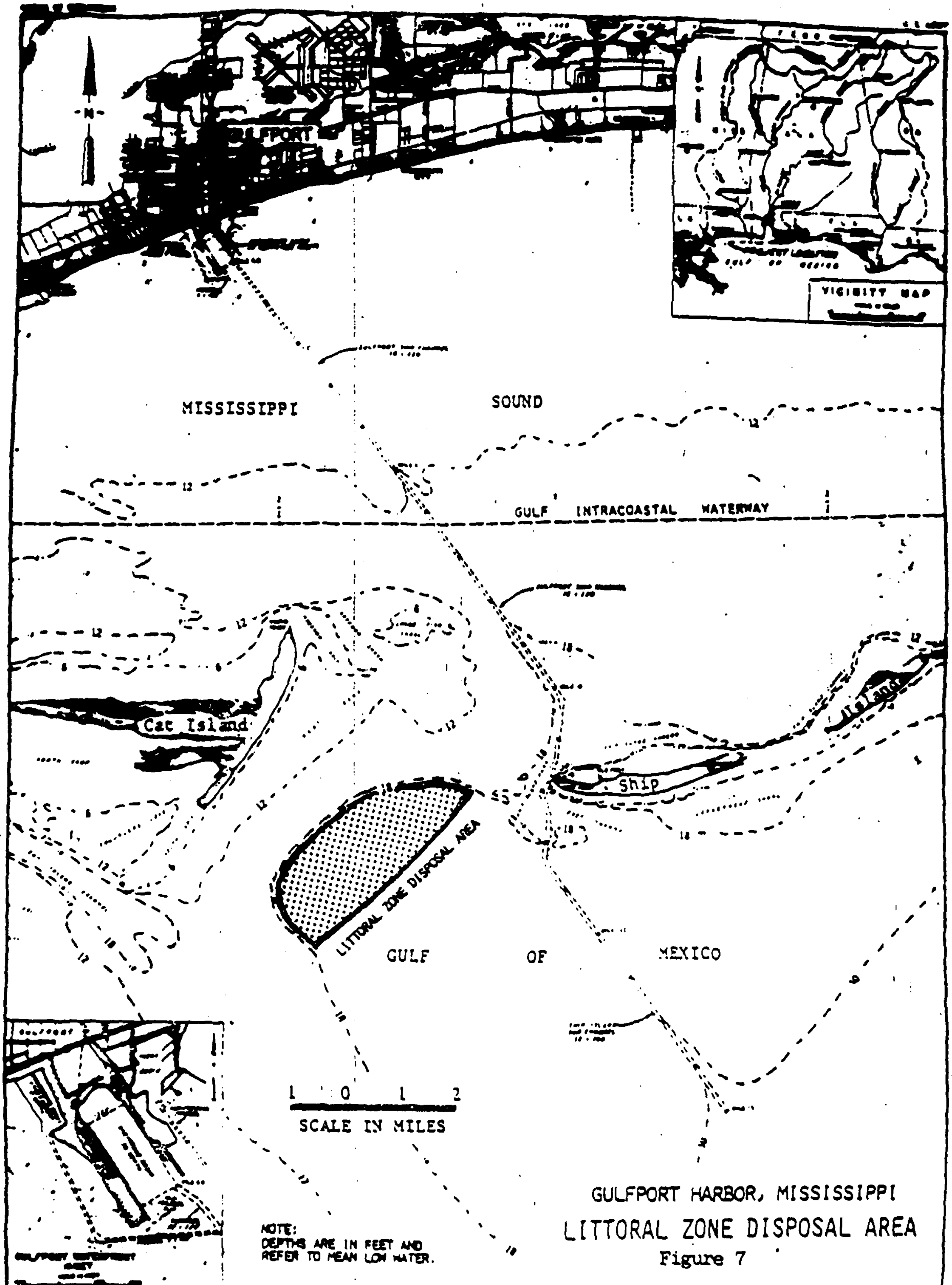
Ship Island will continue a westward drift over the 50-year project life. The Corps has informed us that over this time frame maintenance of the Ship Island Pass Channel would not alter this rate of drift or configuration of the island.

IMPACTS

General Impacts

Both the authorized plan and the Corps NED plan would have similar impacts. The major difference between these plans is the reduced channel widths of the NED plan. These impacts are described in more detail under the Specific Impact Section (see below).

With either plan, 11 miles of the Mississippi Sound Channel would be widened and deepened. The waters in the Sound average about 10 ft. deep (Eleuterius, C., 1976a). This widening and deepening would convert productive shallow fishery and benthic habitat to relatively less valuable deeper waters. White, D.H., and F. Cromartie (1985), in a benthic invertebrate study of the Galveston Bay (Texas) estuary, found no mollusks or polychaetes in the ship channel. Work by Templet (1971) in the Sabine-Neches Waterway system (Louisiana) demonstrated that the benthic population was non-existent in the channels. Espey, Huston, and Associates, Inc. (1977, in studying the Bayport (Texas) ship channel, found only a few benthic individuals as compared with a rather abundant population from a nearby bay bottom.



GULFPORT HARBOR, MISSISSIPPI

LITTORAL ZONE DISPOSAL AREA

Figure 7

The new work material under both alternatives would be taken to select gulf sites a few miles south of Ship Island in waters that average 23 ft. deep. Even though adverse impacts to the benthic community at this site can be expected, this method of disposal is currently viewed as more environmentally acceptable than disposal of dredged material along the channel within the shallower waters of Mississippi Sound. The gulf disposal sites have been approved by the Environmental Protection Agency.

The specific effects of dredged material disposal on the marine ecosystem within the Gulfport Harbor project area are described in Appendix A of Environmental Protection Agency's environmental impact statement for the Pensacola, Fl., Mobile, Al., and Gulfport, Ms., dredged material disposal site designation.. The nature and extent of impacts vary according to the composition of the dredged materials and the physical and biological characteristics of the disposal site (EPA 1986). Adverse impacts from dumping are minimized when dredged sediments are similar to those at the disposal sites and disposal areas are in high-energy dynamic environments of low biological productivity such as deepwaters of the gulf.

Major impact interest is focused on both nekton and benthic forms. Sufficient data to describe the effects of disposal on nekton at the Gulfport site is unavailable (EPA 1986). However, results from MBMR (Wright, 1978) suggest that fish usually are not directly affected by disposal. Local burial of benthic forms may result in temporary changes in the abundance and species composition of fishes. The effects of disposing on marine mammals and reptiles have not been studied; however, the Environmental Protection Agency's environmental impact statement indicated that due to the size and mobility of these species, that no significant direct impacts are expected.

Benthics comprise a group of invertebrates whose life cycle is directly related to sediment type. A study by Vittor and Associates (1982) of the Mississippi Sound and Gulf of Mexico identified over 532 taxa from offshore Mississippi and Alabama, and 437 taxa from Mississippi Sound. In general, macro-infaunal densities in these locations increase dramatically from fall to spring.

Twenty four species of macrofauna were common in the vicinity of the Gulfport ocean disposal sites in January and June 1980 surveys. The more abundant species included the sipunculan, golfingia marine bilobatae, and the polychaetes (Paraprionospio pinnata), (Magelona sp. phyllisae), and (Mediomastus californiensis).

The direct effects of disposal are burial and smothering of benthic organisms (Hirsch et al., 1978). Some motile or active benthic forms are capable of burrowing through deposited dredged material of thicknesses up to 32 cm. (Mauser et al., 1978). Nevertheless, Gulf disposal at Gulfport will likely result in a temporary decline in certain benthic organisms (EPA 1986). However, recolonization typically occurs within several months depending on the nature of the dredged sediments (Oliver et al., 1977). Rates are faster when the dredged sediments are similar to the existing sediments (Hirsch et al., 1978).

Both new work and maintenance material from the Ship Island Pass Channel would also be deposited southeast of Cat Island in a location that would situate the material within the natural littoral drift. This placement is intended to help maintain the natural shoreline processes.

Like the Gulf disposal sites, the area to receive disposal material for the littoral drift renourishment would also be impacted to some degree. A major concern for this area would be the adverse effects on benthic organisms. The tidal passes are characterized by a number of species including the polychaete (Boguea enigmatica), the pelecypod (Semele nuculoides), and (Crassinella lumulata) (Corps 1984). The polychaetes (Brania wellfleetensis) and (Poecilochaetus johnsoni) overlap between tidal passes and offshore areas. As with ocean disposal, the impacts of littoral drift renourishment can be greatly reduced if the dredged sediments are similar to that in the disposal area. We have been informed by the Corps that the substrate to be disposed on and the disposal material will be of similar nature. This is predominantly sand.

A major concern associated with deepening the existing channels is the potential affect on salinity patterns. However, mathematical model analyses conducted by the Corps show that channel deepening should have no appreciable alteration of the normal salinity regime in the project area.

Secondary impacts that cannot be quantified are expected with each project alternative. Even though we cannot quantify these impacts through use of tools such as the Service's Habitat Evaluation Procedures (HEP), such modifications should be qualitatively considered and offsetting methods employed. The following paragraphs address examples of such secondary impacts.

Each of the proposed alternatives would temporarily increase suspended sediment in Mississippi Sound and gulf waters. Cumulatively, this could adversely impact aquatic resources. A primary factor determining the degree of impacts is the time of year dredging is conducted. As a general rule, we believe that dredging is more damaging when performed during peak fish and shellfish spawning and migration periods in late winter, spring, and early summer. The Corps' Mississippi Sound Study provides maps showing seasonal usage of these waters for fish activities such as spawning, migration, and general distribution for many species of fish.

The resuspension of sediment as a result of dredging, including contaminants such as heavy metals, pesticides, hydrocarbons, etc., must also be considered. Contaminants such as these are often concentrated in sediment. If not disturbed, contaminants in sediment are in many cases not readily available to the biota. However, if disrupted by activities such as dredging operations, the contaminated material can become available to the biota through resuspension in the water column. An even greater problem may arise when contaminated sediment is disposed of where it is in contact with the air. Oxidation, pH, and temperature changes may then occur, greatly increasing the toxicity of the material.

A toxicity and bioaccumulation test was conducted with sediment from three locations within the upper reaches of the Gulfport Harbor's Mississippi Sound Channel (EPA, March 11, 1988). The toxicity of the three sediment

samples on oysters, pink shrimp (Penaeus duorarum), and lugworms (Arenicola cristata) was reported as minimal. Chemical analyses were also performed on sediments from each of the three locations and on three types of marine organisms exposed to those sediments during a 10-day bioaccumulation test. Sediments and organisms were analyzed for residues of selected chlorinated hydrocarbon pesticides, PCB's, chloropyrifos, petroleum hydrocarbons, and nine heavy metals. Test results on sediment showed that pesticides and PCB's were not present at detectable levels and did not accumulate in tissues. Some metals were found in sediments at the three sites which included arsenic, cadmium, copper, selenium and zinc.

Analysis of variance (ANOVA) at the 0.05 probability level revealed that concentrations of metals in oysters (Crassostrea virginica), or lugworms (Arenicola cristata) exposed to sediment from the three sites were not significantly greater than concentrations of metals in animals exposed to a reference sediment. Although statistically significant differences were determined for selenium and zinc in shrimp (Penaeus duorarum), appropriate consideration should be given to the magnitude of these numbers. This is because when differences between mean values for organisms exposed to sediment from a reference site and mean values for organisms exposed to a test site are not greater than an order of magnitude may not indicate a bioaccumulation potential without further confirmation by a more definitive study (EPA, March 11, 1988).

Aliphatic and aromatic petroleum hydrocarbon residues were found in shrimp and lugworms after the 10-day exposure study, but not in oysters. Concentrations of residues of both aliphatic and aromatic petroleum hydrocarbons were higher in lugworms exposed to Sites 2 or 3 than in lugworms exposed to a reference sediment. No statistically significant differences could be found for shrimp (EPA March 11, 1988).

Port Expansion Impacts

With either plan under consideration, the Port proposes to expand its docking facilities by filling about 29 acres of shallow water on the west side of the harbor. Fill would be obtained from the turning basin. This new work material would be dredged as part of the federal project, with placement of the fill constituting an activity subject to Section 404 permit requirements. The placement of fill would result in the permanent loss of habitat for fish, shellfish, benthic organisms, and wildlife resources. Impacts caused by resuspension of sediments and associated turbidity could also occur. In addition, storm water runoff from the expanded port area as well as originating from the existing facility has also been given consideration. A committee composed of federal and state natural resource management agencies has been studying these impacts and means by which they can be mitigated. This will be addressed in more detail in the Discussion Section.

Specific Impacts

This section describes impacts that are specific to both the Authorized and NED plans. The major difference between these plans is the reduced channel widths of the NED plan.

Authorized Plan

The authorized plan requires the existing 30 ft. by 220 ft. Mississippi Sound Channel to be deepened to 36 ft. and widened to 300 ft. All of the dredged material would be taken to designated gulf disposal sites. While the impacts of gulf disposal cannot be specifically quantified, most state and federal natural resource agencies now believe that this method of disposal is less damaging than placing the material in Mississippi Sound. Studies conducted to date have not been able to quantify the specific differences in the impacts of gulf disposal versus those associated with shallow water disposal in Mississippi Sound.

The areal extent of shallow waterbottoms lost as a result of widening and deepening the Ship channel can be determined. The average depths of Mississippi Sound are about 10 ft. With this plan, 11 miles of channel would be widened from 220 ft. to 300 ft. This would result in a loss of about 106 acres of shallow water habitat. Use of this area by large numbers of benthic organisms and some fish species would be lost. The existing 32 ft. by 300 ft. Ship Island Pass Channel would be deepened and widened to 38 ft. by 400 ft. While impacts of widening the channel in this area would be similar to those occurring in Mississippi Sound, some differences could be expected due to the greater water depths and current velocities found in the pass.

New work and maintenance material from the Ship Island Pass Channel would be placed southeast of Cat Island so as to maintain the natural littoral drift patterns. Disposal of dredged material in this location may impair the commercial shrimp fishery. As such we recommend that the Corps closely coordinate this disposal with the Mississippi Bureau of Marine Resources in regard to time and area. Mitigation measures such as seasonal restrictions may also be in order. In addition, increased turbidity and possible temporary benthic community losses are foreseen.

Impacts of deepening and widening the Bar Channel from 32 ft. by 300 ft. to 38 ft. by 400 ft. are also not quantifiable. Water depths in this area average about 23 ft., which could help lessen those impacts which are otherwise anticipated for the more shallow waters of Mississippi Sound.

NED Plan

Under the NED plan, the existing 30 ft. by 220 ft. Mississippi Sound Channel would be deepened to 36 ft. but not widened. As with the authorized plan, all of the new work and maintenance material would be taken to gulf disposal sites. Elimination of channel widening under this plan would avoid the loss of 106 acres of shallow waterbottoms and reduce the amount of both new work and maintenance material that would go to the gulf sites (see Table 4) as proposed under the authorized plan.

The Ship Island Pass and Bar Channels would be deepened to 38 ft. but not widened. Even though the adverse environmental impacts of dredging in these areas cannot be quantified, we believe that relatively less impacts would occur as a result of this reduced dredging and disposal of material associated with this plan. Furthermore, the amount of material dredged from the Ship Island Pass Channel that would be disposed within the littoral drift system southeast of Cat Island would also be reduced.

This alternative would avoid deepening 106 acres of shallow waters in Mississippi Sound and reduce the amount of dredged material placed in the gulf. As such, of the two alternatives, impacts associated with the NED plan would be much less than those which are expected with the authorized plan.

EVALUATION METHODS

The only impact of this project that can be quantified to a finite degree is the permanent loss of 29 acres of shallow water habitat that would occur as a result of port expansion. A Committee composed of the Service, National Marine Fisheries Service, Environmental Protection Agency, U.S. Army Corps of Engineers, Mississippi State Docks, Mississippi Bureau of Marine Resources, and Mississippi Bureau of Pollution Control assumed the responsibility for deriving suitable mitigation measures for the loss of 29 acres. It was the collective view of this Committee that the mitigation for shallow water habitat losses should basically be secured through mitigation measures such as the creation and restoration of oyster reefs and wetlands or by enhancement of water quality. The replacement amount would be based on ratios determined by the Committee. The specifics of these mitigation measures are described in the Discussion Section.

Other impacts associated with dredging and disposal are not quantifiable at this time. In such cases, avoidance or minimization of impacts through reduction of project dimension is a major mitigation measure. Further studies are needed relative to dredged material disposal in the gulf, shallow water disposal, and deepening of shallow waters, before impacts could be quantified and detailed compensation measures recommended.

DISCUSSION

With either of the two plans under consideration, a loss of 29 acres of open waterbottoms would occur for expansion of Port facilities. Several means of mitigating these open water losses are currently being considered by an environmental committee. It has been generally agreed by the committee that the most logical means of assessing impacts and determining mitigation is by ratios based on general knowledge of the area and literature review. Means of compensation being considered include: a) creation of waterbottoms, b) restoration of previously disturbed wetlands to productive wetlands, c) enhancement of previously impacted wetlands to enhance/restore wetland functions, d) creation of oyster and fishing reefs, and e) preservation of areas which may otherwise be developed. The committee intends to select several mitigation measures and apply certain credits in terms of ratios which would be used by the applicant as

guidelines for developing a mitigation plan for compensating the impacts associated with the Port expansion.

The authorized plan would also result in the loss of 106 acres of shallow water habitat in Mississippi Sound as a result of channel widening. While impacts to benthic organisms and fishery resources would occur, no means of quantifying such losses have been developed. Therefore, we strongly recommend that the best mitigation measure is to avoid impacts associated with channel widening as proposed by the NED plan. In addition, the impacts of dredging the Ship Island Pass and Bar Channel are not quantifiable given the current information base. Placing material southeast of Cat Island to maintain the natural littoral drift processes is not expected to cause any appreciable fish and wildlife damages provided that dredged material is similar to native material in the disposed site. However, it is possible that this disposal could conflict with shrimp fishing and we recommend that the area of disposal as well as the time be closely coordinated with the Mississippi Bureau of Marine Resources. The impacts of deepening the existing channels by 6 to 8 ft. are also virtually unknown. Mathematical model studies completed by the Corps indicate the deepening would have no appreciable effect on the salinities within either the Mississippi Sound or Bar Channels.

Turbidity increases associated with dredging activity could have an impact on larval fish movement through the Ship Island Pass Channel. As such, we recommend that dredging in this area be conducted only in November-December at which time movement of larval marine finfish and shellfish is lowest.

Of the two plans currently recommended by the Corps, the NED plan appears to result in the least environmental damages. This would result from the smaller channel designs that would not only avoid the loss of 106 acres of shallow water in Mississippi Sound but also reduce the amount of dredged material to be placed in the gulf site and the littoral drift zone southeast of Cat Island.

More detailed site-specific studies relative to impacts associated with dredging and open water disposal are needed to accurately predict project damages and for implementing adequate mitigation measures. However, such studies should only be conducted after careful consideration has been given to their effectiveness in providing information to reviewing and lead agencies that will allow rational and environmentally sound decisions. Such studies should meet the approval of interested federal and state environmental agencies.

RECOMMENDATIONS

The following recommendations provide measures which avoid, minimize, and attempt to compensate unavoidable project impacts:

1. Of the two proposed plans, the NED plan is the least environmentally damaging. This plan would have less adverse impacts to Mississippi Sound in terms of losses of shallow waterbottoms, sedimentation, turbidity, and resuspension of pollutants than would the Authorized Plan. It should be selected for implementation.

2. With either plan, 29 acres of shallow water habitat is proposed to receive disposal material and be totally filled for port expansion. **We recommend that the mitigation measures recommended by the natural resource agency committee be implemented to compensate for these losses.**

Other measures which could further help to mitigate adverse impacts are:

a. Dredging in the Ship Island Pass only be conducted in the late fall months (November - December) to avoid peak larval fish migration activities occurring at this location during the other times of the year.

b. Monitoring of the Sound and Gulf disposal sites should be conducted to determine if the chemical levels within the dredged materials are creating any environmental problems. Before and after project monitoring of salinity and dissolved oxygen should be performed.

c. Measures should be taken by the Corps to avoid conflicts this project may have with the CBRA relative to the Cat Island unit.

d. Close coordination should be made with the Mississippi Bureau of Marine Resources to assure that placing dredged material southeast of Cat Island for island nourishment will not interfere with fishing activities.

e. Mitigation should occur prior to, or concurrently with, project initiation.

SERVICE POSITION

Of the two plans currently proposed, the NED plan appears to be the least damaging alternative. Nevertheless, adverse impacts would occur with the NED plan. Some of these impacts can be quantified while others cannot.

The adverse impacts of permanent filling of aquatic habitat, such as the 29-acre port expansion proposed with either alternative, are more predictable than those impacts occurring from dredging in Mississippi Sound and placing the material in the Gulf. However, the longterm chronic impacts of open water disposal could have serious repercussions. It is unfortunate that studies to date have not quantified such adverse impacts. Studies are needed at the project site since the conditions of substrate type, pollution levels, salinity regimes, etc., vary greatly at other ports along the Mississippi and Alabama coasts. Without specific and adequate impact studies at a number of project sites, it is difficult to assess environmental damages, and more importantly, to assure that the proposed mitigation would successfully offset these detrimental impacts. If mitigation efforts are not thorough and effective, then given the amount of channel expansion and maintenance, there is a danger that cumulative impacts of dredging and filling throughout the Mississippi Sound could

severely impact a multimillion dollar seafood industry and the overall environmental quality of this area. In view of our collective inability to quantitatively assess the adverse impacts of dredging and disposal activities such as those proposed at Gulfport, best professional judgment must be relied upon. In doing so we often recommend measures we feel would avoid adverse impacts. Such measures include reducing channel sizes and placing dredged material in the deeper waters of the gulf in lieu of placing the material in the more confined shallower waters of Mississippi Sound.

It is imperative for making environmentally sound decisions relative to longterm impacts of dredging and disposal that site-specific studies be conducted. Such studies should be adequately coordinated with all Federal and State reviewing agencies. Until such work is completed the Service, Corps, and other agencies will continue to use best professional judgments relative to assessing project impacts. And as in the past, the varying opinions by all agencies regarding what is environmentally sound will continue until more accurate data does become available. For these reasons, the Service supports such impacts studies but only after they have the concurrence of the reviewing agencies.

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SECTION D-3

EFFECTS OF SEDIMENT FROM THE GULFPORT, MISSISSIPPI, CHANNEL ON REPRESENTATIVE MARINE ORGANISMS

EFFECTS OF SEDIMENT FROM THE GULFPORT, MISSISSIPPI, CHANNEL ON REPRESENTATIVE MARINE ORGANISMS

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ABSTRACT

A toxicity and bioaccumulation test was conducted with sediment from three locations in the Gulfport, Mississippi, Channel. Three types of marine organisms from benthic and epibenthic habitats were exposed to sediment samples from each of the three sites for 10 days in flowing, natural seawater; a reference sediment collected near Gulfport was used as a control. The purpose of the test was to evaluate, in the laboratory, the toxicity of the sediment samples and the potential for bioaccumulation of chemicals from the sediments. A 96-hour toxicity test was conducted with the suspended particulate phase (SPP) of each sediment sample; the purpose was to compare toxicity of the whole sediment to that of the SPP.

The toxicity of each of the three sediment samples was minimal. Exposure to the sediments for 10 days had little observable adverse effect on oysters (Crassostrea virginica) or pink shrimp (Penaeus duorarum). Survival of oysters was 96% in the reference sediment and 90% in Site 1, 2, and 3 sediment; shrimp survival was 100% in the reference sediment and ≥ 94% in site sediment. Survival of lugworms (Arenicola cristata) exposed to Site 2 and Site 3 sediment was not significantly different from survival in the reference sediment (82%, 80% and 90%, respectively). However, survival of lugworms exposed to Site 1 sediment was significantly ($\alpha = 0.05$) less than survival of lugworms in the reference sediment (72% vs. 90%).

The SPP of the three sediments had little effect on mysids (Mysidopsis bahia). Survival in 100% SPP of all samples was ≥ 80%.

The results of the bioaccumulation test are reported in a separate document.

INTRODUCTION

In accord with an agreement with the U.S. Army Corps of Engineers (CE), Mobile District, tests were conducted with sediment from three locations in the Gulfport, Mississippi, Channel to determine toxicity to representative marine organisms and the potential for bioaccumulation of chemicals from the sediment samples. Ten-day tests with the solid phase (whole sediment) and 96-hour (h) tests with the suspended particulate phase (SPP) of each sediment sample and a reference sediment were conducted at the U.S. EPA Environmental Research Laboratory, Gulf Breeze (ERL/GB), Florida during October 1987.

The chemical analyses of sediments and animal tissues also were conducted at ERL/GB, and the results are reported in a separate document.

MATERIALS AND METHODS

Test Materials

The reference and site sediments tested were collected by ERL/GB and CE, Mobile District, personnel on 1 October 1987, and transported to ERL/GB on the day of collection. Another Site 1 sample was collected on 7 October to replace the initial Site 1 sample which was collected at the wrong site. The sediment samples and reference sediment samples were placed in a large cooler at ERL/GB and maintained at approximately 4°C. Before testing, the reference sediment was sieved to remove any large organisms; subsamples were combined and mixed well. The Site 2 and 3 sediment samples were made up of larger particles than the reference sediment or Site 1 sediments. A characterization of the Channel sediment samples and the reference

sediment is contained in Table 1.

Sodium lauryl sulfate was used as a reference toxicant to gauge the condition of the test animals for the SPP tests. The chemical used was manufacutred by Sigma Chemical Company, No. L-5730, Lot 42F-0039, and was approximatley 95% pure.

Test Animals

For the solid-phase (whole-sediment) tests, three types of marine organisms from benthic and epibenthic habitats were tested. They were lugworms (*Arenicola cristata*), oysters (*Crassostrea virginica*), and pink shrimp (*Penaeus duorarum*). The polychaetes were purchased from a bait dealer in St. Petersburg, Florida; the oysters were collected from East Bay, near ERL/GB; and the shrimp were purchased from a local bait dealer. All animals were maintained for at least 48 h at ERL/GB where they were acclimated to test conditions. There were no observed deaths of oysters or shrimp during the acclimation period. Those polychaetes that would not contract when touched were not considered suitable for testing and were discarded.

Mysids (*Mysidopsis bahia*) for the SPP and reference toxicant tests were cultured at ERL/GB. Mysids (5 ± 1 days old) were fed *Artemia salina* nauplii (32 to 48 h post-hydration) during holding and testing.

Test Water

Natural seawater pumped from Santa Rosa Sound into the ERL/GB seawater system was used for all tests. For the solid-phase test, the water was not filtered as it was pumped into elevated reservoirs.

There it was aerated and allowed to flow by gravity into the wet laboratory, where it was siphoned from an open trough into the test aquaria. For the SPP tests, the seawater was filtered through sand and 20-μm fiber filters; salinity was controlled at 20 ± 2 parts per thousand by the addition of deionized water, and temperature was controlled at 25 ± 1°C by a commercial chiller and/or heater.

Test Methods

Test methods for the solid-phase tests were based on those of U.S. Environmental Protection Agency/Corps of engineers (1977) and methods for the SPP test were after U.S. Environmental Protection Agency (1985). To prepare for the exposure of lugworms, oysters, and shrimp, approximately 7 liters (l) of reference sediment was placed ineach of fifteen 20-gallon (76-l) glass aquaria. This resulted in a layer of reference sediment approximately 30 millimeters (mm) deep. After about 1 h, seawater flowed into each aquarium at approximately 25 l/h, and the system was allowed to equilibrate for 24 h. After equilibration, the seawater flow was stopped, approximately 3.5 l of the appropriate Gulfport sediment was added to each aquarium (resulting in a layer about 15 mm deep), the sediment was allowed to settle for approximately 1 h, and the seawater flow was resumed. Then 10 lugworms were placed in the back section and 10 shrimp and 10 oysters were placed in the front section of each aquarium. (A nylon screen, 2-mm mesh, had been inserted in each aquarium and secured with silicone sealant in order to separate the lugworms from the predacious shrimp.) It should be noted that only 10 test organism per replicate of each species were used for this test. The numbers were sufficient to

perform a statistical analysis of mortality, and the individuals were of such a size that sufficient biomass was available for chemical analyses to determine bioaccumulation.

The five control (reference sediment) aquaria were prepared at the same time and in the same manner as the Gulfport sediment exposure aquaria except that only the reference sediment was added to each aquarium.

The 10-day solid-phase test was conducted from 20 October 30 October 1987. Water temperature, salinity, pH, and dissolved oxygen were recorded daily. Dead animals were noted and removed from the aquaria daily. At the end of the exposure, the remaining live animals in each aquarium were removed, rinsed with seawater to remove sediment, and were placed separately in flowing seawater to purge their gut. After 24 h, they were placed in acid-cleaned glass jars, then frozen, and later provided to the ERL/GB Chemistry Laboratory for chemical analyses to determine bioaccumulation. Animals from the test populations were treated similarly before the test began to provide information on background concentrations.

To prepare the suspended particulate phase (SPP) of each of the three Gulfport sediment samples, 1,000 milliliters (ml) of chilled seawater was added to a 2-l Erlenmeyer flask. Then, 200 ml of well-stirred sediment was added to the flask. More seawater (800 ml) was added to the flask to bring the contents to the 2-l mark. This 1-part sediment:9-part seawater mixture was placed on a magnetic stirrer and mixed for at least 5 minutes, and then allowed the settle for 1 h. The SPP was then decanted into a separate container, and pH and

dissolved oxygen (DO) concentrations were measured. The SPP of all the sediment samples, including the reference sediment, had to be aerated to increase the DO to acceptable concentrations (≥ 60% of saturation). The appropriate volume of 100% SPP in seawater of seawater only was added to 2-l Carolina culture dishes (the total volume in each dish was 1 l) to prepare the test mixtures and control. The mixtures were than stirred for approximately 5 minutes (min); the DO, pH, temperature and salinity were measured; and test animals were added to the dishes. For all tests, ten animals were placed in each dish in holding cups fabricated by gluing a collar of 363- mesh nylon screen to a 15-centimenter (cm) wide glass Petri dish with silicone sealant; the nylon screen collar was approximately 5 cm high.

After water quality measurements and addition of animals, the dishes were stacked, with a cover on the top dish, and placed in an incubator. The temperature controller was set at 20°C and the light controller at 14 h light:10 h dark. The seawater in all treatments was aerated at a volume estimated to be 100 cubic centimeters/min during the tests. Air was delivered to each dish through polyethylene tubing (0.045-inch inner diameter and 0.062-inch outer diameter) by a small aquarium pump.

Water quality was measured at 24-h intervals, but daily counts of animals were not made because in some cases the turbidity of the sediments prevented 24-h observations of test animals. After 96 h, the tests were terminated. When necessary, the cups were flushed with seawater until the animals became visible, and live animals were then removed by pipette and counted. Suitability of the procedure was

ensured by counting the control animals, placing them back in the holding cup and flushing them with seawater, and then recounting them.

Tests with the SPP prepared with sediment from each site were conducted 20-24 October 1987; a reference toxicant test with mysids from the same population was conducted 21-25 September 1987.

Statistical Analyses

A one-way Analysis of Variance was performed on the survival data for lugworms (S.A.S., 1982), but there was no statistical analyses of the data from the SPP tests because no median effect (50% mortality) occurred. Mortality data from the mysid reference toxicant test were subjected to statistical analyses, however. The 96-h LC50 (the concentration lethal to50% of the test animals, after 96 h of exposure) were calculated by using the logit metod (Stephan, 1977). The 95% confidence limits were also calculated.

RESULTS AND DISCUSSION

Sediment from three sites in the Gulfport, Mississippi, Channel had little observable adverse effects on oysters or pink shrimp after a 10-day exposure. Survival of oysters was 96% in the reference sediment and $\geq$ 90% in Site 1, 2, and 3 sediment; shrimp survival was 100% in the reference sediment and $\geq$ 94% in site sediment (Table 2).

Survival of lugworms exposed to sediment from Site 1 and Site 2 was not significantly different from survival of lugworms exposed to the reference sediment; survival for both sites was $\geq$ 80%. However, when compared to lugworm survival in the reference sediment, survival of lugworms exposed to Site 1 sediment was significantly (α = 0.05) less (Table 2). The cause of the effect could not be determined by

this study; chemical analysis of the Site 1 sediment may provide correlative information.

The suspended particulate phase (SPP) of the sediments did not cause significant adverse effects on mysids. When up to 100% SPP was tested, survival was $\geq$ 80% (Table 3). Results of the reference toxicant test showed that the mysids were in suitabale condition for testing; the 96-h LC50 was 6.5 ppm with 95% confidence limits of 4.8 to 8.8 ppm. Our experience and the literature (Roberts et al., 1982) show that the 96-h LC50 of sodium lauryl sulfate for mysids is usually 5 to 8 ppm.

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Table 1. Characterization of three sediment samples from the Gulfport, Mississippi, Channel and a reference sediment from near Gulfport for water content, silt-clay (< 62 micrometers), and organic carbon. Values reported are mean values.

Sediment	Water (%)	Silt-Clay (%)	Organic Carbon (%)
Reference	62.4	95.9	5.6
Site 1	73.3	98.2	7.2
Site 2	64.8	27.9	4.5
Site 3	70.5	89.6	8.5

Table 2. Results of a 10-day laboratory exposure of lugworms *Arenicola cristata*, oysters (*Crassostrea virginica*), and pink shrimp (*Penaeus duorarum*) to sediment from the Gulfport, Mississippi, Channel, along with a reference sediment. Animals that were alive at the end of the exposure are given; numbers of animals per replicate at the beginning of the test were 10 lugworms, oysters, and pink shrimp.

	Replicate	Lugworms	Oysters	Shrimp
Reference Sediment	1	10	10	10
	2	8	10	10
	3	8	8	10
	4	9	10	10
	5	11[a]	10	10
	Total	46	48	50
Site 1	1	6	10	10
	2	6	8	10
	3	8	10	10
	4	8	9	9
	5	8	10	9
	Total	36	47	48
Site 2	1	9	10	10
	2	8	10	10
	3	7	8	10
	4	8	9	10
	5	9	9	10
	Total	41	46	50
Site 3	1	7	9	10
	2	8	9	9
	3	9	8	8
	4	9	10	10
	5	7	9	10
	Total	40	45	47

[a] An extra lugworm was apparently placed in the aquarium at beginning of test.

Table 3. Results of acute toxicity tests conducted with mysids (*Mysidopsis bahia*) and the suspended particulate phase (SPP) of sediment from three sites in the Gulfport, Mississippi, Channel and a reference sediment from near Gulfport. The percentage of animals alive after 96 hours of exposure is given.

	Exposure Concentration (% SPP[a])					
Test material	Control	1%	10%	25%	50%	100%
Reference Sediment	100	90	100	100	80	100
Site 1	100	100	100	100	100	100
Site 2	100	90	100	100	90	80
Site 3	100	100	100	100	100	100

[a] The SPP (suspended particulate phase) was prepared by mixing 1 part sediment with 9 parts seawater (v:v), allowing the mixture to settle for 1 hour, and decanting the unsettled portion.

Table 4. Water quality measurements during a 10-day laboratory exposure of marine organisms to sediment from the Gulfport, Mississippi, Channel. The pH ranged from 8.12 to 8.37 in all aquaria for the period of the test.

	Test day									
	1	2	3	4	5	6	7	8	9	10
Temp. (°C)	21.5	20.0	21.0	21.0	21.5	21.0	21.0	20.0	20.0	20.0
Salinity (‰)	28.0	27.0	28.0	29.0	28.0	30.0	27.0	28.0	29.0	28.0
DO (ppm)										
Reference										
Rep. 1	5.8	6.8	6.6	5.7	5.1	5.2	4.3	6.2	5.7	6.4
2	6.0	6.8	6.5	6.1	6.4	4.7	5.4	6.2	6.0	6.7
3	5.9	6.8	6.3	5.7	6.0	3.4	6.2	6.6	5.9	6.4
4	5.8	6.5	6.8	5.6	6.2	4.4	4.9	5.3	5.8	5.9
5	5.9	6.4	6.4	6.1	6.0	4.9	5.4	6.2	5.8	6.4
Site 1										
Rep. 1	6.0	6.9	6.7	5.6	6.8	3.6	5.8	5.5	5.9	6.0
2	6.0	6.3	6.1	6.3	6.9	3.6	4.4	5.7	5.7	6.2
3	6.0	6.8	6.4	5.4	6.9	4.5	4.7	5.5	5.9	6.4
4	5.7	6.4	6.7	5.7	6.7	3.1	3.4	6.0	5.3	5.9
5	6.2	6.7	7.1	6.0	6.9	4.4	3.1	4.8	4.8	6.3
Site 2										
Rep. 1	6.1	6.5	6.8	6.3	6.9	4.2	4.9	6.3	5.4	6.2
2	6.1	6.8	6.6	6.1	6.7	3.3	3.7	4.8	5.5	6.3
3	6.0	6.5	6.2	5.8	6.7	3.0	3.4	5.1	6.0	6.5
4	6.0	6.7	6.6	5.5	6.8	3.8	4.4	6.3	5.2	6.4
5	6.0	7.0	6.7	5.7	6.7	4.2	5.8	6.1	5.8	6.4
Site 3										
Rep. 1	6.2	6.6	6.8	6.4	6.8	4.3	3.2	5.3	4.7	6.4
2	6.0	6.4	6.7	6.0	6.6	3.2	3.3	4.7	4.9	6.2
3	5.9	6.4	6.4	5.7	6.6	3.6	3.0	5.7	4.8	6.4
4	6.1	6.7	6.1	6.2	6.6	4.3	3.8	4.8	5.4	6.3
5	5.9	6.4	6.8	6.1	6.7	3.8	4.5	6.2	5.2	6.0
Ambient	NT	NT	NT	NT	NT	6.9	7.3	8.9	8.2	6.7

NT - Not taken

SECTION D-4

CHEMICAL ANALYSES OF SEDIMENT FROM GULFPORT, MISSISSIPPI, AND TISSUES OF MARINE ORGANISMS EXPOSED TO THE SEDIMENT

CHEMICAL ANALYSES OF SEDIMENT FROM THREE SITES IN GULFPORT, MISSISSIPPI AND TISSUSES OF MARINE ORGANISMS EXPOSED TO THE SEDIMENT

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ABSTRACT

Chemical analyses were performed on sediments from three sites in Gulfport Mississippi, and on three types of marine organisms exposed to these sediment samples during a 10-day bioaccumulation test conducted by the Dredged Materials Research Team of the Gulf Breeze Laboratory. Five replicates of each sediment and type of organism were analyzed for residues of selected chlorinated hydrocarbon pesticides, PCBs, chlorpyrifos (Dursban), petroleum hydrocarbons, and 9 heavy metals. The purpose of chemical analyses was to determine if residues were detectable in the sediment and if they accumulated in tissues of organisms exposed to the sediment. Samples of each type of organism and sediment were analyzed prior to use in a bioaccumulation test.

Residues of selected pesticides or PCBs were not detected in sediments or animal tissues before or after exposure but several metals were detected in sediments and in tissues of organisms before and after exposure. Using analysis of variance (ANOVA) at the 0.05 probability level, concentrations of metals in oysters (Crassostrea virginica), or lugworms (Arenicola cristata) exposed to sediment from sites 1, 2 or 3 were not significantly greater than concentrations of metals in animals exposed to a reference sediment. Although statistically significant differences were determined for selenium and zinc in shrimp (Penaeus duorarum), appropriate consideration should be given to the magnitude of these numbers. When differences between mean values for organisms exposed to sediment from a reference site and mean values for organisms exposed to a test site are not greater than an order of magnitude may not indicate a bioaccumulation potential without further confirmation by a more definitive study.

Aliphatic and aromatic petroleum hydrocarbon residues were found in shrimp and lugworms after the 10-day exposure study, but not in oysters. Concentrations of residues of both aliphatic and aromatic petroleum hydrocarbons were higher in lugworms exposed to Sites 2 or 3 than in lugworms exposed to a reference sediment. No statistically significant differences could be found for shrimp.

INTRODUCTION

In accord with an agreement between the U.S. Army Corps of Engineers (CE), Mobile District, and EPA's Gulf Breeze Research Laboratory, chemical analyses were performed on sediment from Sites 1, 2 and 3 in Gulfport, Mississippi and on three species (shrimp, oyster, and lugworm) of marine organisms exposed to these sediments during a bioaccumulation test. Five replicates of each sediment and organism were analyzed for the following chemical residues: PCBs, selected chlorinated hydrocarbon pesticides, chlorpyrifos (Dursban), selected heavy metals, and two petroleum hydrocarbon fractions (aliphatic and aromatic). These analyses were performed on sediments and organisms before the bioaccumulation test and on organisms after a bioaccumulation test. Chemical analyses were performed by gas-liquid chromatography for pesticides, PCBs, and petroleum hydrocarbons, and inductively coupled argon plasma emission spectroscopy (ICAP) for heavy metals. Methods of chemical analyses were modified and validated at the EPA Gulf Breeze Research Laboratory, except for the petroleum hydrocarbon method. This method was used as recommended by the U.S. Army Corps of Engineers Implementation Manual (EPA/CE, 1977).

MATERIALS AND METHODS

Test Sediments and Animals

Samples of sediments and test organisms were obtained from the ERL/GB Dredged Materials Research Team prior to initiation of the bioaccumulation test. After the 10-day exposure period, five replicates of each test organism from each test sediment, and the reference sediment, were collected and maintained at approximately 4°C until chemical analyses were performed.

Methods of Chemical Analyses

A. Chlorinated Hydrocarbon Pesticides and PCBs

Tissue samples were weighed into a 150-mm by 25-mm screw-top test tube and homogenized three times with 10 ml of acetonitrile with a Willems Polytron Model PT 20-ST (Brinkman Instruments, Westbury, NY). Following each homogenization, the test tube was centrifuged (1600x g) and the liquid layer decanted into a 120-ml oil sample bottle. Seventy-five ml of a 2% (w/v) aqueous sodium sulfate and 10 ml of petroleum ether were added to the bottle and the contents shaken for 1 minute. After the layers separated, the solvent was pipetted into a 25-ml concentrator tube and the extraction with petroleum ether was repeated two more times. The combined solvent extract was concentrated to 1 ml on a nitrogen evaporator in preparation for cleanup.

Cleanup columns were prepared by adding 3 g of PR-grade florisil (stored at 130°C) and 2 g of anhydrous sodium sulfate (powder) to a 200-mm by 9-mm i.d. Chromaflex column (Kontes Glass Co., Vineland, NJ) and rinsing with 20 ml of hexane. Tissue and sediment extracts were transferred to the column with two additional 2-ml volumes of hexane. Pesticides and PCBs were eluted with 20 ml of 5% (v/v) diethyl ether in hexane.

Quantitations of pesticides were made with external standard methods. All standards were obtained from the EPA pesticide repository. PCB reference standard, obtained from U.S. EPA Chemical Repository, Washington, DC, was described by Sawyer (1978). Analyses were performed on a Hewlett-Packard Model 5710 gas chromatograph equipped with a ^{63}Ni electron-capture detector. Separations were performed by using a 182-cm by 2-mm i.d. glass column packed with 2% SP2100 (Supelco, Inc., Bellefonte, PA) on 80-100 mesh Supelcoport. Other gas chromatographic parameters were: flow rate of the 10% methane-in-argon carrier gas, 25 ml/min; column temperature, 190°C; inlet temperature, 200°C, and detector temperature, 300°C.

Recoveries of PCBs and pesticides from spiked samples and detection limits for pesticides and petroleum hydrocarbons are shown in Table 1.

B. Heavy Metals

One to two grams of tissue or sediment were weighed into a 40 ml reaction vessel. Five ml of concentrated nitric acid (Baker Chemical Instra-Analyzed) were added and the samples digested for 2 to 4 h at 70°C in a tube heater. Digestion was continued, with vessels capped, for 48 h at 70°C. After digestion, samples were transferred to 15-ml tubes and diluted to 10 ml for aspiration into a Jarrell-Ash AtomComp 800 Series inductively-coupled argon-plasma emission spectrometer (ICP). This instrument acquires data for 15 elements simultaneously. A solution of ten percent nitric acid/distilled water was analyzed between samples to prevent carryover of residues from one sample to the next. Standards were used to calibrate the instrument initially and adjustments were made when necessary. Concentrations are reported in two significant figures as our method allows, and were not corrected for percentage recovery.

C. Petroleum Hydrocarbons

Ten grams of tissue or sediment were weighed into culture tubes and extracted as described by J.S. Warner (1976). Sample extracts were concentrated to approximately 0.50 ml for gas chromatographic analyses. Analyses were performed on a Hewlett Packard gas chromatograph (GC) equipped with flame ionization detection. Separations were performed by using a 182-cm by 2-mm i.d. glass column packed with 3% OV101 on 100/120 mesh Supelcoport. Helium carrier gas was used at a flow of 30 mℓ/min.

Quality Assurance of Chemical Analyses

All standards used for quantitations of pesticides were obtained from EPA's repository in Las Vegas, Nevada. Standard solutions of metals were obtained from J.T. Baker Chemical Co., Phillipsburg, NJ, and were Instra-Analyzed quality. Dotriacontane was obtained from Alltech Associates, Deerfield, Illinois, and was used as an internal standard to quantitate petroleum hydrocarbons.

A part of our quality assurance procedures includes fortification of samples of organisms and sediments with selected chemicals to evaluate the entire analytical system during the period of time quantitative analyses of test organisms and sediments are performed. Separate samples were fortified with selected pesticides, petroleum hydrocarbons, and metals. Reagent and glassware blanks were analyzed to verify that the analytical system was not contaminated with chemical residues that could interfere with quantitations.

Statistical Analyses

Residue data were analyzed according to guidance in the Implementation manual (EPA/CE, 1977).

Cochran's test was performed to determine whether variance of data

sets were homogeneous. Then analysis of variance (ANOVA) was used to compare mean tissue concentration in animals exposed to each dredged material sample. When the calculated F-value exceeded the tabulated value, the Student-Newman-Keuls multiple-range test was used to determine which dredged material mean was significantly different from the Reference mean. These analyses were performed using Statistical Analysis System (SAS) procedures (SAS Institute Inc.).

RESULTS AND DISCUSSION

Analyses of Pesticides and PCBs

Results of spiked samples shown in Table 1 indicate that the extraction and quantitation techniques were adequate for determining concentrations of chemical residues in organisms and sediments used in the bioaccumulation study. Results of reageant and glassware blank analyses verified that residues of pesticides, PCBs, petroleum hydrocarbons, metals, or other contaminants were not present prior to the analyses of test organisms and sediments.

Prior to the bioaccumulation test, chemical analyses were performed on samples of each group of organisms to determine concentrations of PCBs and pesticides. Results of these analyses are shown in Table 2, and indicate that residues of pesticides and PCBs were not present in concentrations above the detection limits. Results from pesticides and PCB analyses on replicate samples of sediment from reference sites and Sites 1, 2, and 3 show that none of these residues were present above detection limits.

After organisms were exposed to a reference sediment or test sediments they were analyzed for pesticides, petroleum hydrocarbons, and metals. Results show that residues of pesticides and PCBs did not accumulate in organisms from exposure to reference sediment (Table 3). Results of chemical analyses of organisms exposed to sediment from Sites 1, 2 and 3 are shown in Tables 4, 5 and 6 respectively. These results indicate that no pesticides or PCBs accumulated in tissues.

Analyses of Metals

Replicate samples of each group of organisms were analyzed for selected metals before and after a 10-day bioaccumulation test. Results from the pretest analyses are shown in Table 7 with method detection limit given

for each element. Method blanks were analyzed regularly with no detectable residues of these elements. Results in Table 8 show that each sediment contained some heavy metals.

Concentrations of selected metals in samples of oysters exposed for 10 days to a reference sediment or sediment samples from Sites 1, 2 or 3 are shown in Table 9. Test for homogeneity of variances was performed on arsenic (As), cadmium (Cd), copper (Cu), selenium (Se), and zinc (Zn). Results in Tables 10 through 15 show that calculated C-values were not greater than the tabulated C-values at the 95-percent confidence level for those tested. However, for cadmium and lead, means of all elemental concentrations in oysters exposed to sediment from Sites 1, 2 and 3 were similar to means of these elemental concentrations in oysters exposed to the reference sediment. Therefore, no further statistical analyses were performed. Analysis of varinace (ANOVA) of oyster bioaccumulation data for arsenic, copper, selenium, and zinc shown in Tables 16 through 19. No significant differences were detected for lead at the 0.05 alpha level.

Concentrations of metals in samples of lugworms exposed for 10 days to sediments from a reference site or sediment samples from Sites 1, 2 or 3 are shown in Table 20. Results of tests for homogeneity of variance (Tables 21 and 22) indicate variance are homogenous and no need for transformation.

Results from analyses of variance for copper and zinc bioaccumulation in lugworms are shown in Tables 23 and 24. No significant differences were found at the 0.05 probability level.

Concentrations of metals in samples of shrimp exposed for 10 days to sediment from a reference site or sediments from Sites 1, 2 or 3 are shown in Table 25. Results of test for homogeniety of variances performed on

arsenic, cadmium, copper, lead and zinc residues detected in shrimp tissues are shown in Tables 26 through 30. Log transformation was not necessary. Because of similarity of means or because means from the sites were less than means for the reference sediment no further analyses were necessary for copper and lead. Results from analysis of variance of arsenic, selenium, and zinc data are shown in Tables 31 through 33, and indicate no significant differences for sites.

Analyses of Petroleum Hydrocarbons

Samples of organisms and sediments were analyzed for residues of both aliphatic and aromatic petroleum hydrocarbons before a 10-day bioaccumulation study was performed. Shrimp and oysters did not contain detectable concentrations of these residues; however, lugworms contained both aliphatic and aromatic hydrocarbons fractions (Table 34). Sediments from Site 1 contained higher concentrations of both aliphatic and aromatic hydrocarbons than did reference or Site 2 sediments. Sediment from Site 3 did not contain detectable residues of either fraction.

After exposure to these sediments, replicate samples of oysters did not contain constence detectable concentrations of either aliphatic or aromatic petroleum hydrocarbons (Table 35). Many samples did not contain detectable residues, therefore, statistical analyses could not be performed for oysters.

Both aliphatic and aromatic petroleum hydrocarbon residues were detected in shrimp after a 10-day exposure to sediment from a reference site or Sites, 1, 2 or 3 (Table 36). Since mean concentration in tissues exposed to reference sediment were similar to mean concentrations in tissue exposures to Sites 1, 2 or 3; no further statistical analyses were performed for aromatic petroleum hydrocarbon residues. Analysis of

variance was performed on aliphatic hydrocarbon residues (Table 37), but statistical differences were not found between residue concentrations in shrimp exposed to reference sediment and residue concentrations in shrimp exposed to Site 1, 2 or 3.

Analysis of variance was performed on aliphatic and aromatic petroleum hydrocarbon residues in lugworms exposed to a reference sediment or sediment from Sites 1, 2 or 3 (Table 38). Differences were found for both fractions (Tables 39 and 40). Student-Newman-Keuls multiple-range test was performed then to compare concentrations to determine which sites were different from a reference (Table 41 and 42). Both Sites 2 and 3 were different for aliphatic and aromatic petroleum hydrocarbon residues.

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Table 1. Percentage recovery of chlorinated hydrocarbon pesticides, and petroleum hydrocarbons spiked in tissues of organisms and reference sediment used in a bioaccumulation study. Method detection limit for each compound is given in µg/g wet tissue weight. Standard deviation is shown in parentheses.

Compound	Spike Concentration (µg/g)	N	Lugworm	N	Shrimp	N	Oyster	Sediment	Method Detection Limit (µg/g)
Aldrin	0.010	10	91 (7)	4	87 (11)	7	78 (10)	a	0.0020
BHC Isomers									
Alpha	0.0050		a		a		a	a	0.00080
Beta	0.010		a		a		a	a	0.0040
Gamma (lindane)	0.010	11	110 (9)	7	106 (8)	8	99 (8)	a	0.0020
Delta	0.020		a		a		a	a	0.0020
Chlordane	0.10		a		a		a	a	0.040
Chlorpyrifos (Dursban)	0.10	2	90 (3)	5	92 (4)	6	94 (12)	a	0.010
DDE	0.020	11	97 (8)	7	99 (10)	8	86 (9)	a	0.0040
DDD	0.040	12	100 (6)	7	97 (5)	8	95 (8)	a	0.0080
DDT	0.060	12	95 (7)	7	95 (8)	8	90 (10)	a	0.010
Dieldrin	0.020	11	95 (7)	7	95 (5)	8	97 (9)	a	0.0040
Endrin	0.020	9	100 (10)	7	98 (7)	8	99 (10)	a	0.010
Endosulfan I	0.020		a		a		a	a	0.010
Endosulfan II	0.020		a		a		a	a	0.010
Endosulfan Sulfate	0.10		a		a		a	a	0.050
Heptachlor	0.010	12	94 (6)	7	92 (6)	8	94 (4)	a	0.0020
Heptachlor epoxide	0.010	11	89 (3)	7	97 (8)	8	92 (12)	a	0.010
Hexachlorobenzene	0.050		a		a		a	a	0.0020
Methoxychlor	0.10	12	93 (7)	7	92 (5)	10	93 (8)	a	0.030
Mirex	0.10	11	88 (8)	7	91 (7)	10	71 (25)	a	0.020
PCBs	0.50		a		a		a	a	0.10
Toxaphene	1.0		a		a		a	a	0.20
Petroleum Hydrocarbons									
Aliphatic	1.0-5.0					8	90 (13)		0.50
Aromatic	1.0-1.5					8	87 (11)		0.50
Total									0.50

a Analytes were not spiked for recovery.

Table 2. Results of selected chlorinated pesticide and PCB analyses in replicate samples of three marine organisms analyzed piror to exposure to sediment during a bioaccumulation study with sediments from Gulfport, MS.

Common Name	Replicate	Lugworm 1	Lugworm 2	Shrimp 1	Shrimp 2	Oyster 1	Oyster 2
Aldrin		ND	ND	ND	ND	ND	ND
BHC Isomers		ND	ND	ND	ND	ND	ND
Alpha		ND	ND	ND	ND	ND	ND
Beta		ND	ND	ND	ND	ND	ND
Gamma (lindane)		ND	ND	ND	ND	ND	ND
Delta		ND	ND	ND	ND	ND	ND
Chlordane		ND	ND	ND	ND	ND	ND
Chlorpyrifos (Dursban)		ND	ND	ND	ND	ND	ND
DDE		ND	ND	ND	ND	ND	ND
DDD		ND	ND	ND	ND	ND	ND
DDT		ND	ND	ND	ND	ND	ND
Dieldrin		ND	ND	ND	ND	ND	ND
Endrin		ND	ND	ND	ND	ND	ND
Endosulfan I		ND	ND	ND	ND	ND	ND
Endosulfan II		ND	ND	ND	ND	ND	ND
Endosulfan Sulfate		ND	ND	ND	ND	ND	ND
Heptachlor		ND	ND	ND	ND	ND	ND
Heptachlor epoxide		ND	ND	ND	ND	ND	ND
Hexachlorobenzene		ND	ND	ND	ND	ND	ND
Methoxychlor		ND	ND	ND	ND	ND	ND
Mirex		ND	ND	ND	ND	ND	ND
PCBs		ND	ND	ND	ND	ND	ND
Toxaphene		ND	ND	ND	ND	ND	ND

ND = Not detected, see Table 1 for detection limits.

Table 3. Results of selected chlorinated pesticide and PCB analyses in replicate samples of three marine organisms analyzed after 10 day exposure to a reference sediment during a bioaccumulation study with sediment from Gulfport, MS.

Common Name	Replicate	Lugworm					Shrimp					Oyster				
		1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Aldrin		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
BHC Isomers		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Alpha		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Beta		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Gamma (lindane)		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Delta		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chlordane		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chlorpyrifos (Dursban)		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
DDE		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
DDD		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
DDT		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Dieldrin		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Endrin		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Endosulfan I		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Endosulfan II		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Endosulfan Sulfate		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Heptachlor		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Heptachlor epoxide		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Hexachlorobenzene		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Methoxychlor		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Mirex		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
PCBs		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Toxaphene		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

ND = Not detected, see Table 1 for detection limits.

Table 4. Results of selected chlorinated pesticide and PCB residues in replicate samples of three marine organisms analyzed after 10 day exposure to sediment from Gulfport - Site 1 during a bioconcentration study.

Common Name	Replicate	Lugworm					Shrimp					Oyster				
		1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Aldrin		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
BHC Isomers		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Alpha		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Beta		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Gamma (lindane)		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Delta		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chlordane		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chlorpyrifos (Dursban)		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
DDE		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
DDD		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
DDT		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Dieldrin		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Endrin		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Endosulfan I		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Endosulfan II		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Endosulfan Sulfate		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Heptachlor		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Heptachlor epoxide		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Hexachlorobenzene		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Methoxychlor		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Mirex		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
PCBs		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Toxaphene		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

ND = Not detected, see Table 1 for detection limits.

Table 5. Results of selected chlorinated pesticide and PCB residues in replicate samples of three marine organisms analyzed after 10 day exposure to sediment from Gulfport - Site 2 during a bioconcentration study.

Common Name	Replicate	Lugworm					Shrimp					Oyster				
		1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Aldrin		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
BHC Isomers		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Alpha		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Beta		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Gamma (lindane)		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Delta		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chlordane		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chlorpyrifos (Dursban)		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
DDE		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
DDD		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
DDT		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Dieldrin		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Endrin		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Endosulfan I		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Endosulfan II		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Endosulfan Sulfate		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Heptachlor		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Heptachlor epoxide		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Hexachlorobenzene		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Methoxychlor		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Mirex		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
PCBs		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Toxaphene		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

ND = Not detected, see Table 1 for detection limits.

Table 6. Results of selected chlorinated pesticide and PCB residues in replicate samples of three marine organisms analyzed after 10 day exposure to sediment from Gulfport - Site 3 during a bioconcentration study.

Common Name	Lugworm					Shrimp					Oyster				
Replicate	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Aldrin	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
BHC Isomers	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Alpha	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Beta	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Gamma (lindane)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Delta	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chlordane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chlorpyrifos (dursban)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
DDE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
DDD	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
DDT	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Dieldrin	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Endrin	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Endosulfan I	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Endosulfan II	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Endosulfan Sulfate	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Heptachlor	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Heptachlor epoxide	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Hexachlorobenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Methoxychlor	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Mirex	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
PCBs	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Toxaphene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

ND = Not detected, See Table 1 for detection limits.

Table 7. Concentrations of selected metals in tissues of organisms that were determined as background residues before the organisms were used in a bioaccumulation study with Gulfport sediment. Method detection limits for each element is given in µg/g wet tissue weight.

Pre-Test Organism	Replicate	Concentrations in µg/g wet tissue weight								
		As	Cd	Cr	Cu	Hg	Ni	Pb	Se	Zn
Shrimp	1	4.6	ND	0.89	9.5	a	0.43	ND	1.3	21
	2	4.8	ND	1.3	6.0	ND	0.49	ND	1.2	21
Lugworm	1	2.1	ND	2.5	2.4	ND	1.2	ND	ND	13
	2	2.1	ND	2.4	2.7	ND	1.3	ND	ND	13
Oyster	1	2.5	0.33	0.50	5.5	a	ND	ND	ND	230
	2	2.0	0.29	ND	5.3	a	0.56	ND	ND	210
		[b]Method Detection Limits								
		0.375	0.125	0.25	0.15	0.625	0.25	0.50	0.375	0.125

[a] Sample was contaminated by residues from standard that was analyzed immediately before this sample.

[b] Based on final vol. of 50 mℓ and a sample weight of 2 g (maximum sample size).

ND = Not detected.

Table 8. Concentrations of selected metals in sediment samples from a reference site and test Sites 1, 2, and 3 from Gulfport.

Sediment Location	Replicate	Concentrations in µg/g wet weight								
		As	Cd	Cr	Cu	Hg	Ni	Pb	Se	Zn
Reference	1	a	20	5.1	3.1	ND	7.3	ND	33	23
	2	a	20	5.5	3.2	ND	7.6	ND	34	24
Site 1	1	a	20	5.6	47	ND	5.3	< 13[b]	25	51
	2	a	23	6.2	50	ND	6.0	< 12[b]	29	54
Site 2	1	a	21	7.1	3.0	ND	7.0	ND	34	26
	2	a	20	6.6	2.8	ND	7.3	ND	37	26
Site 3	1	a	ND	3.9	0.51	ND	5.5	ND	25	20
	2	a	ND	3.5	0.61	ND	5.1	ND	22	18

ND = not detected, see Table 7 for detection limits.

[a] Interference from other metals prevented accurate quantitation.

[b] Usual background correction techniques could not be applied because of the intense interference; therfore, without subtracting background, lead may be present but not in quantities greater than these shown.

Table 9. Concentrations of selected metals in samples of oysters used in a bioaccumulation study with sediments from test Sites 1, 2, and 3 in Gulfport and a reference Site.

Sediment Location	Replicate	Concentrations in µg/g wet tissue weight								
		As	Cd	Cr	Cu	Hg	Ni	Pb	Se	Zn
Reference	1	2.8	0.30	ND	ND	ND	ND	ND	2.1	280
	2	2.6	0.35	0.56	4.4	ND	ND	ND	1.8	400
	3	2.9	0.29	ND	1.7	ND	ND	ND	1.7	240
	4	3.3	0.35	ND	4.2	ND	ND	ND	1.6	380
	5	2.3	0.22	ND	1.1	ND	ND	0.84	1.4	260
Site 1	1	2.6	0.36	ND	2.6	ND	ND	ND	1.2	330
	2	2.1	0.23	ND	0.54	ND	ND	ND	1.0	280
	3	3.0	0.30	ND	2.8	ND	ND	1.6	1.7	290
	4	2.9	0.31	ND	1.7	ND	ND	0.66	1.8	260
	5	2.9	0.35	ND	2.3	ND	ND	ND	1.7	290
Site 2	1	3.3	0.37	ND	4.9	ND	ND	0.67	2.4	440
	2	3.1	0.37	ND	4.4	ND	ND	1.6	1.8	370
	3	3.7	0.38	ND	3.8	ND	ND	1.1	2.5	380
	4	2.8	0.32	0.31	3.1	ND	ND	ND	1.8	340
	5	2.7	0.32	ND	ND	ND	ND	0.69	1.5	220
Site 3	1	3.1	0.32	ND	3.5	ND	ND	ND	1.8	350
	2	3.4	0.38	ND	4.8	ND	ND	1.1	2.1	410
	3	3.1	0.30	ND	1.1	ND	ND	ND	1.8	340
	4	2.8	0.30	ND	2.0	ND	ND	ND	1.7	270
	5	2.3	0.22	ND	0.68	ND	ND	0.62	1.2	200

ND = not detected.

Table 10. Statistical analysis of arsenic (µg/g wet tissue) in samples of oysters used in the Gulfport sediment study.

Replicate (n = 5)	Reference	Sites 1	Sites 2	Sites 3
1	2.8	2.6	3.3	3.1
2	2.6	2.1	3.1	3.4
3	2.9	3.0	3.7	3.1
4	3.3	2.9	2.8	2.8
5	2.3	2.9	2.7	2.3
Sum of data, Σx =	13.9	13.5	15.6	14.7
Mean $\overline{X}$ =	2.78	2.70	3.12	2.94
Sum of squared data, Σx^2 =	39.19	36.99	49.32	43.91
CSS = $\Sigma x^2 - \frac{(\Sigma X)^2}{n}$	0.548	0.540	0.648	0.692
Variance	0.137	0.135	0.162	0.173

$C = \frac{0.173}{0.607} = 0.285$ $\qquad C = \frac{s^2(max)}{\sum_{i=1}^{4} s^2 i}$ $\qquad$ Where s^2i is estimate of variance of i^{th} site.

Chi square (4,4) = 0.6287

Since calculated C is less than tabulated Chi square, variances are homogeneous.

Table 11. Statistical analysis of cadmium (μg/g wet tissue) in samples of oysters used in the Gulfport sediment study.

Replicate (n = 5)	Reference	Sites 1	2	3
1	0.30	0.36	0.37	0.32
2	0.35	0.23	0.37	0.38
3	0.29	0.30	0.38	0.30
4	0.35	0.31	0.32	0.30
5	0.22	0.35	0.32	0.22
Sum of data, Σx =	1.51	1.55	1.76	1.52
Mean $\bar{X}$ =	0.302	0.310	0.352	0.304
Sum of squared data, Σx^2 =	0.468	0.491	0.623	0.475
CSS = $\Sigma x^2 - \frac{(\Sigma X)^2}{n}$	0.011	0.011	0.003	0.013
Variance	0.003	0.003	0.001	0.003

$C = \frac{0.003}{0.010} = 0.30$ $\quad C = \frac{s^2(max)}{\sum_{i=1}^{4} s^2 i}$ Where $s^2 i$ is estimate of variance of i^{th} site.

Chi square (4,4) = 0.6287

Since calculated C is greater than tabulated Chi square, variances are homogeneous, and transformation is unnecessary. Because of similarity in means, no further analysis is necessary.

Table 12. Statistical analysis of copper (µg/g wet tissue) in samples of oysters used in the Gulfport sediment study.

Replicate (n = 5)	Reference	Sites 1	Sites 2	Sites 3
1	ND	2.6	4.8	3.5
2	4.4	0.54	4.4	4.8
3	1.7	2.8	3.8	1.1
4	4.2	1.7	3.1	2.0
5	1.1	2.3	ND	0.68
Sum of data, Σx =	11.4	9.94	16.2	12.0
Mean $\bar{X}$ =	2.85	1.98	4.05	2.41
Sum of squared data, Σx^2 =	41.1	23.0	67.4	40.9
$CSS = \Sigma x^2 - \frac{(\Sigma X)^2}{n}$	8.61	3.31	1.81	11.7
Variance =	2.87	0.828	0.603	2.94

ND = Not detected

$C = \frac{2.94}{7.24} = 0.406$

Chi square (4,4) = 0.6287

Since calculated C is less than tabulated Chi square, variances are homogenous and transformation unncesessary.

Table 13. Statistical analysis of lead (μg/g wet tissue) in samples of oysters used in the Gulfport sediment study

Replicate (n = 5)	Reference	Sites 1	2	3
1	ND	ND	0.67	ND
2	ND	ND	1.67	1.1
3	ND	1.6	1.1	ND
4	ND	0.66	ND	ND
5	ND	ND	0.69	0.62
Sum of data, Σx =		2.16	4.06	1.72
Mean $\bar{X}$ =		1.13	1.01	0.86
Sum of squared data,				
Σx^2 =				
CSS = $\Sigma x^2 - \frac{(\Sigma X)^2}{n}$				
Variance =				

ND = Not detected

Since data values were not detected for reference sediment, and since data values were similar for Sites and near the detection limit of 0.50, no further analysis was performed.

Table 14. Statistical analysis of selenium (μg/g wet tissue) in samples of oysters used in the Gulfport sediment study.

Replicate (n = 5)	Reference	Sites 1	Sites 2	Sites 3
1	2.1	1.2	2.4	1.8
2	1.8	1.0	1.8	2.1
3	1.7	1.7	2.5	1.8
4	1.6	1.8	1.8	1.7
5	1.4	1.7	1.5	1.2
Sum of data, Σx =	8.6	7.4	10.0	8.6
Mean, $\bar{X}$ =	1.72	1.48	2.00	1.72
Sum of squared data, Σx^2 =	15.06	11.46	20.74	15.22
CSS = $\Sigma x^2 - \frac{(\Sigma X)^2}{n}$ =	0.268	0.508	0.704	0.428
Variance =	0.067	0.127	0.185	0.107

$C = \frac{0.185}{0.486} = 0.380$

Chi square (4,4) = 0.6287

Since calculated C is less than tabulated Chi square, variances are homogeneous.

Table 15. Statistical analysis of zinc (μg/g wet tissue) in samples of oysters used in the Gulfport sediment study.

Replicate (n = 5)	Reference	Sites 1	2	3
1	280	330	440	350
2	400	280	370	410
3	240	290	380	340
4	380	260	340	270
5	260	290	220	200
Sum of data, Σx =	1560	1450	1750	1570
Mean, $\overline{X}$ =	312	290	350	314
Sum of squared data, Σx^2 =	508000	423100	639800	519100
CSS = $\Sigma x^2 - \frac{(\Sigma X)^2}{n}$ =	21280	2600	26400	26120
Variance =	5320	650	6600	6530

$$C = \frac{6530}{19100} = 0.341$$

Chi square (4,4) = 0.6287

Since calculated C is less than tabulated Chi square, variances are homogeneous and transformation is unnecessary.

Table 16. Analysis of variance of arsenic accumulation in shrimp from Gulfport sediment.

Analysis of Variance Procedure

Dependent Variable: Weight

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	0.51750	0.17250	1.14	0.3641
Error	16	2.4280	0.15175		
Corrected Total	19	2.94550			

C.V.	Root MSE	PPM Mean
13.5026	0.3895	2.8850

Table 17. Analysis of variance of copper accumulation in oysters used in the Gulfport sediment study.

Analysis of Variance Procedure

Dependent Variable: Weight

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	10.2602	3.420	1.88	0.179
Error	14	25.5080	1.822		
Corrected Total	17	35.768			
		C.V.	Root MSE		PPM Mean
		48.96	1.349		2.75

Table 18. Analysis of variance of selenium accumulation in oysters used in the Gulfport sediment study.

Analysis of Variance Procedure

Dependent Variable: Weight

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	0.678	0.2260	1.86	0.177
Error	16	1.944	0.1215		
Corrected Total	19	2.62			
		C.V.	Root MSE		PPM Mean
		20.14	0.3485		1.730

Table 19. Analysis of variance of zinc accumulation in oysters used in the Gulfport sediment study.

Analysis of Variance Procedure

Dependent Variable: Weight

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	0.6780	0.2260	1.86	0.177
Error	16	1.944	0.1215		
Corrected Total	19	2.622			
		C.V.	Root MSE		PPM Mean
		20.148	0.3485		1.730

Table 20. Concentrations of selected metals in samples of lugworms used in a bioaccumulation study with sediments from a reference site, and three sites from Gulfport.

Sediment Location	Replicate	Concentrations in ug/g wet tissue weight								
		As	Cd	Cr	Cu	Hg	Ni	Pb	Se	Zn
Reference	1	ND	ND	ND	1.6	a	ND	2.4	2.1	8.3
	2	ND	ND	ND	3.8	a	ND	ND	ND	17
	3	ND	ND	ND	4.8	1.0	ND	ND	ND	25
	4	ND	ND	ND	3.0	ND	ND	ND	ND	19
	5	ND	ND	ND	3.1	2.3	ND	ND	ND	20
Site 1	1	ND	ND	ND	2.4	ND	ND	ND	ND	14
	2	ND	ND	ND	2.9	ND	ND	ND	ND	14
	3	ND	ND	ND	3.3	ND	ND	ND	ND	16
	4	ND	ND	ND	5.2	ND	ND	ND	ND	18
	5	ND	ND	ND	4.8	ND	ND	ND	ND	21
Site 2	1	ND	ND	2.3	3.8	ND	ND	ND	ND	16
	2	ND	ND	0.83	3.9	ND	ND	ND	ND	17
	3	ND	ND	ND	4.9	ND	ND	ND	ND	15
	4	ND	ND	ND	5.4	ND	ND	ND	ND	24
	5	ND	ND	ND	3.7	ND	ND	ND	ND	26
Site 3	1	ND	ND	ND	2.7	ND	ND	ND	ND	11
	2	ND	ND	ND	2.4	ND	ND	ND	ND	16
	3	ND	ND	ND	4.6	ND	ND	ND	ND	14
	4	ND	ND	ND	6.9	ND	ND	ND	ND	20
	5	ND	ND	ND	3.9	ND	ND	ND	ND	16

[a] Contaminated by residue from previous standard.

Table 21. Statistical analysis of copper ($\mu g/g$ wet tissue) in samples of lugworms used in Gulfport sediment test.

Replicate (n = 5)	Reference	Sites 1	2	3
1	1.6	2.4	3.8	2.7
2	3.8	2.9	3.9	2.4
3	4.8	3.3	4.9	4.6
4	3.0	5.2	5.4	6.9
5	3.1	4.8	3.7	3.9
Sum of data, Σx =	16.3	18.6	21.7	20.50
Mean $\bar{X}$ =	3.26	3.72	4.34	4.10
Sum of squared data, Σx^2 =	58.65	75.14	96.51	97.03
CSS = $\Sigma x^2 - \frac{(\Sigma X)^2}{n}$	5.512	5.948	2.33	12.98
Variance =	1.37	1.48	0.583	3.24

$C = \frac{3.24}{6.67} = 0.48$

Chi square (4.4) = 0.6287

Since calculated C is less than tabulated chi square, variances are homogenous and transformation is unnecessary.

Table 22. Statistical analysis of zinc (μg/g wet tissue) in samples of lugworms used in Gulfport sediment study.

Replicate (n = 5)	Reference	Sites 1	Sites 2	Sites 3
1	8.3	14	16	11
2	17	14	17	16
3	25	16	15	14
4	19	18	24	20
5	20	21	26	16
Sum of data, Σx =	89.3	83.0	98.0	77.0
Mean $\overline{X}$ =	17.8	16.6	19.6	15.4
Sum of squared data,				
Σx^2 =	1743	1413	2022	1229
CSS = $\Sigma x^2 - \frac{(\Sigma X)^2}{n}$	148	35.2	101.2	43.2
Variance =	37.2	8.80	25.3	10.8

$$C = \frac{37.2}{82.1} = 0.45$$

Chi square (4.4) = 0.6287

Since calculated C is greater than tabulated Chi square, variances are homogenous and transformation is unnecessary.

Table 23. Analysis of variance of copper accumulation in lugworms used in the Gulfport sediment study.

Analysis of Variance Procedure

Dependent Variable: Weight

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	3.337	1.112	0.66	0.585
Error	16	26.77	1.673		
Corrected Total	19	30.109			
		C.V.	Root MSE		PPM Mean
		33.55	1.293		3.855

Table 24. Analysis of variance of zinc accumulation in lugworms used in the Gulfport sediment study.

Analysis of Variance Procedure

Dependent Variable: Weight

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	48.43	16.14	0.79	0.519
Error	16	328.5	20.53		
Corrected Total	19	377.0			
		C.V.	Root MSE		PPM Mean
		26.09	4.531		17.36

Table 25. Concentrations of selected metals in samples of shrimp used in a bioaccumulation study with sediments from a reference site, and three sites from Gulfport.

Sediment Location	Replicate	Concentrations in µg/g wet tissue weight								
		As	Cd	Cr	Cu	Hg	Ni	Pb	Se	Zn
Reference	1	5.5	ND	ND	8.7	a	ND	2.1	2.9	12
	2	5.8	ND	ND	11	a	ND	ND	2.3	12
	3	4.9	ND	ND	13	a	ND	1.6	2.1	13
	4	6.1	ND	ND	8.5	a	ND	4.4	2.4	12
	5	5.1	ND	ND	8.5	ND	ND	1.4	2.1	14
Site 1	1	8.1	ND	ND	11	ND	ND	ND	3.4	13
	2	7.0	ND	0.57	10	ND	0.54	1.3	2.6	13
	3	6.3	ND	ND	8.6	ND	ND	2.5	3.1	11
	4	5.1	ND	2.4	7.7	ND	ND	1.7	2.4	17
	5	7.1	ND	ND	9.5	ND	ND	1.8	3.0	13
Site 2	1	5.5	ND	0.54	8.5	ND	ND	1.8	2.5	17
	2	7.5	ND	ND	7.0	ND	ND	2.2	3.4	14
	3	SL	SL	SL	SL	SL	SL	SL	SL	SL
	4	6.7	ND	ND	11	ND	ND	2.3	3.1	17
	5	5.4	ND	ND	7.5	ND	ND	2.2	2.3	14
Site 3	1	3.5	ND	0.35	5.1	ND	ND	1.5	1.6	11
	2	5.9	ND	ND	8.8	ND	ND	2.0	2.8	11
	3	7.2	ND	ND	8.3	ND	ND	1.8	2.8	11
	4	7.3	ND	ND	8.6	ND	ND	1.9	3.0	16
	5	6.6	ND	ND	10	ND	ND	1.8	3.1	14

ND = Not detected.

SL = Samples lost during analysis.

[a] Contaminated by residues from standard.

Table 26. Statistical analysis of arsenic (μg/g wet tissue) in samples of shrimp used in Gulfport sediment study.

Replicate (n = 5)	Reference	Sites 1	2	3
1	5.5	8.1	5.5	3.5
2	5.8	7.0	7.5	5.9
3	4.9	6.3	SL	7.2
4	6.1	5.1	6.7	7.3
5	5.1	7.1	5.4	6.6
Sum of data, Σx =	27.4	33.6	25.1	30.5
Mean $\bar{X}$ =	5.48	6.72	6.27	6.10
Sum of squared data, Σx^2 =	151.1	230.7	160.5	195.7
CSS = $\Sigma x^2 - \frac{(\Sigma X)^2}{n}$	0.968	4.92	3.04	9.70
Variance =	0.242	1.23	1.01	2.42

$C = \frac{2.42}{4.90} = 0.493$

Chi square (4, 4) = 0.6287

Since calculated C is less than tabulated chi square, variances are homogenous and transformation unnecessary.

SL = Sample lost during analysis.

Table 27. Statistical analysis of copper (μg/g wet tissue) in samples of shrimp used in the Gulfport sediment study.

Replicate (n = 5)	Reference	Sites 1	2	3
1	8.7	11	8.5	5.1
2	11	10	7.0	8.8
3	13	8.6	LS	8.3
4	8.5	7.7	11	8.6
5	8.5	9.5	1.5	10
Sum of data, Σx =	49.7	46.8	34.0	40.8
Mean $\bar{X}$ =	9.94	9.36	8.50	8.16
Sum of squared data, Σx^2 =	510.1	444.5	298.5	346.3
CSS = $\Sigma x^2 - \frac{(\Sigma X)^2}{n}$	16.17	6.45	9.50	13.3
Variance =	4.04	1.61	3.16	3.34

$C = \frac{4.04}{12.15} = 0.332$

Chi square (4,4) = 0.6287

Since calculated C is less than tabulated Chi square, therefore variances are homogeneous and transformation not necessary.

LS = Sample lost during analysis.

Since means are similar no further analysis is necessary.

Table 28. Statistical analysis of lead (μg/g wet tissue) in samples of shrimp used in the Gulfport sediment study.

Replicate (n = 5)	Reference	Sites 1	2	3
1	2.1	ND	1.8	1.5
2	ND	1.3	2.2	2.0
3	1.6	2.5	SL	1.8
4	4.4	1.7	2.3	1.9
5	1.4	1.8	2.2	1.8
Sum of data, Σx =	9.50	7.30	8.50	9.00
Mean $\bar{X}$ =	2.37	1.82	2.12	1.80
Sum of squared data, Σx^2 =	28.2	14.0	18.2	16.3
CSS = $\Sigma x^2 - \underline{(\Sigma X)^2}$	5.72	0.747	0.147	0.140
Variance =	1.90	0.249	0.049	0.035

$C = \frac{1.90}{2.23} = 0.852$

Chi square (4,4) = 0.6287

Since calculated C is greater than tabulated Chi square, therefore variances are not homogeneous and transformation is necessary.

ND = Not detected

SL = Sample lost

Since means are similar no further analysis is necessary.

Table 29. Statistical analysis of selenium (µg/g wet tissue) in samples of shrimp used in the Gulfport sediment study.

Replicate (n = 5)	Reference	Sites 1	Sites 2	Sites 3
1	2.9	3.4	2.5	1.6
2	2.3	2.6	3.4	2.8
3	2.1	3.1	SL	2.8
4	2.4	2.4	3.1	3.0
5	2.1	3.0	2.3	3.1
Sum of data, Σx =	11.8	14.5	11.3	13.3
Mean $\bar{X}$ =	2.36	2.90	2.82	2.66
Sum of squared data, Σx^2 =	28.2	42.6	32.7	36.8
CSS = $\Sigma x^2 - \frac{(\Sigma X)^2}{n}$	0.432	0.640	0.788	1.472
Variance =	0.108	0.160	0.263	0.368

$C = \frac{0.368}{0.899} = 0.409$

Chi square (4,4) = 62887

Since calculated C is less than tabulated Chi square, variances are homogeneous and transformation is not necessary.

SL = Sample lost during analysis.

Table 30. Statistical analysis of zinc (μg/g wet tissue) in samples of shrimp used in the Gulfport sediment study.

Replicate (n = 5)	Reference	Sites 1	Sites 2	Sites 3
1	12	13	17	11
2	12	13	14	11
3	13	11	SL	14
4	12	17	17	16
5	14	13	14	14
Sum of data, Σx =	63	67	62	66
Mean $\bar{X}$ =	12.6	13.4	15.5	13.2
Sum of squared data, Σx^2 =	797	917	970	890
CSS = $\Sigma x^2 - \frac{(\Sigma X)^2}{n}$	3.2	19.2	9.0	18.8
Variance =	0.800	4.80	3.00	4.70

$C = \frac{4.80}{13.30} = 0.360$ $\quad C = \frac{s^2(max)}{\sum_{i=1}^{4} s^2 i}$ Where s^2 is estimate of variance of i^{th} site.

Chi square (4,4) = 0.6287

Since calculated C is less than tabulated Chi square, variances are homogeneous and log transformation unnecessary.

Since means for Sites are less than Reference mean, no further analyses necessary.

SL = Sample lost during analysis.

Table 31. Analysis of variance of arsenic accumulation in shrimp used in the Gulfport sediment study.

Analysis of Variance Procedure

Dependent Variable: Weight

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	3.9407	1.313	1.06	0.396
Error	15	18.643	1.242		
Corrected Total	18	22.584			
		C.V.	Root MSE		PPM Mean
		18.166	1.114		6.136

Table 32. Analysis of variance of selenium accumulation in shrimp used in the Gulfport sediment study.

Analysis of Variance Procedure

Dependent Variable: Weight

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	0.8400	0.2800	1.26	0.323
Error	15	3.331	0.222		
Corrected Total	18	4.171			
		C.V.	Root MSE		PPM Mean
		17.59	0.471		2.678

Table 33. Analysis of variance of zinc accumulation in shrimp used in the Gulfport sediment study.

Analysis of Variance Procedure

Dependent Variable: Weight

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	20.431	6.81	2.04	0.152
Error	15	50.200	3.34		
Corrected Total	18	70.631			
		C.V.	Root MSE		PPM Mean
		13.47	1.829		13.57

Table 34. Concentrations of aliphatic and aromatic fractions of petroleum hydrocarbons in replicate samples of three marine organisms. Each group of organisms was anlayzed and after exposure to sediment from Gulfport, MS in a bioaccumulation study. Concentrations are given in μg/g wet tissue.

Sample Origin	Lugworm					Shrimp					Oyster					Pre-test Sediment	
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2
Pre-test																	
Aliphatic	11.2	13	NA	NA	NA	SL	ND	NA	NA	NA	ND	ND	NA	NA	NA		
Aromatic	5.3	3.8	NA	NA	NA	ND	ND	NA	NA	NA	ND	ND	NA	NA	NA		
Site 1																	
Aliphatic	6.8	6.3	7.4	5.2	6.0	3.4	1.2	7.0	3.0	3.3	16	ND	ND	ND	ND	42	66
Aromatic	1.2	ND	ND	ND	0.52	ND	3.9	ND	ND	0.77	1.5	ND	ND	ND	1.2	2.1	3.6
Site 2																	
Aliphatic	21	27	21	34	40	1.4	0.75	2.0	2.5	3.7	0.84	ND	0.66	ND	ND	2.3	ND
Aromatic	7.3	7.0	4.7	6.7	5.6	ND	0.74	ND	ND	ND	ND	1.1	0.87	ND	ND	ND	ND
Site 3																	
Aliphatic	13	25	24	31	31	3.2	2.1	10	1.1	2.7	1.2	ND	ND	ND	ND	ND	ND
Aromatic	5.3	7.8	6.2	7.2	9.5	0.65	0.82	1.6	ND	ND	ND	ND	ND	2.8	ND	ND	ND
Reference																	
Aliphatic	12	19	8.2	5.1	9.0	0.76	1.8	0.68	3.6	0.93	0.80	ND	ND	ND	ND	5.6	2.2
Aromatic	1.2	5.4	0.90	2.1	1.2	ND	3.5	4.6	5.5	1.1	1.6	ND	ND	ND	ND	1.2	ND

ND = Not detected

NA = Sample not available for analyses.

SL = Sample lost during analyses.

Table 35. Statistical analysis of petroleum hydrocarbons (µg/g wet tissues) in oysters used in the Gulfport Study.

Replicate	Reference		Sites					
			1		2		3	
	ALH	ARH	ALH	ARH	ALH	ARH	ALH	ARH
1	0.80	1.6	16	1.5	0.84	ND	1.2	ND
2	ND	ND	ND	ND	ND	1.1	ND	ND
3	ND	ND	ND	ND	0.66	0.87	ND	ND
4	ND	ND	ND	ND	ND	ND	ND	2.8
5	ND	ND	ND	1.2	ND	ND	ND	1.9
Sum, Σx =	0.80	1.6	16	2.7	1.5	1.97	1.2	4.7
Mean $\overline{X}$ =	0.80	1.6	16	1.35	0.75	0.985	1.2	2.35
Sum of squared data,								
Σx^2 =	0.64	2.56	256	3.69	1.14	1.96	1.44	11.45
CSS =	0.0	0.0	0.0	0.045	0.016	0.026	0.0	0.405
Variance =	.	.	.	0.045	0.016	0.026	.	0.405

ND = Not detected.

C (ALH) = 0.016/0.016 = 1.0 Chi square (4, 4) = 0.6284

Since calculated C is greater than tabulated chi square, variances are not homogenous and transformation is necessary.

C (ARH) = 0.405/0.476 = 0.85 Chi square (4, 4) = 0.6284

Since calculated C is greater than tabulated Chi square, variances are not homogenous and transformation is necessary.

Table 36. Statistical analysis of petroleum hydrocarbons (μg/g wet tissues) in shrimp used in the Gulfport Study.

Replicate	Reference		Sites					
			1		2		3	
	ALH	ARH	ALH	ARH	ALH	ARH	ALH	ARH
1	0.76	ND	3.4	ND	1.4	ND	3.2	0.65
2	1.8	3.5	1.2	3.9	0.75	0.74	2.1	0.82
3	0.68	4.6	7.0	ND	2.0	ND	10	1.6
4	3.6	5.5	3.0	ND	2.5	ND	1.1	ND
5	0.93	1.1	3.3	0.77	3.7	ND	2.7	ND
Sum, Σx =	7.77	14.7	17.9	4.67	10.35	0.74	19.1	3.07
Mean $\bar{X}$ =	1.55	3.67	3.58	2.33	2.07	0.74	3.82	1.02
Sum of squared data,								
Σx^2=	18.10	64.8	81.89	15.8	26.46	0.548	123.15	3.65
CSS =	6.03	10.8	17.80	4.89	5.03	0.0	50.1	0.513
Variance =	1.50	3.61	4.45	4.89	1.26	.	12.5	0.257

ND = Not detected.

C (ALH) = 12.5/19.7 = 0.634 Chi square (4, 4) ≈ 0.6287

Since calculated C is greater than tabulated chi square, variances are not homogenous and transformation is necessary.

C (ARH) = 4.89/8.75 = 0.558 Chi square (4, 4) = 0.6287

Since calculated C is greater than tabulated Chi square, variances are homogenous and transformation is unnecessary.

Since means for sites are less than mean for reference for aromatic petroleum hydrocarbons no further analyses necessary.

Table 37. Analysis of variance of aliphatic petroleum hydrocarbon accumulation in shrimp used in the Gulfport sediment study.

Analysis of Variance Procedure

Dependent Variable: Weight

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	0.2185	0.07283	1.70	0.2063
Error	16	0.6839	0.042474		
Corrected Total	19	0.9024			

C.V.	Root MSE	PPM Mean
39.93	0.2067	0.5176

Table 38. Statistical analysis of petroleum hydrocarbons (µg/g wet tissues) in lugworms used in the Gulfport Study.

Replicate	Reference		Sites					
			1		2		3	
	ALH	ARH	ALH	ARH	ALH	ARH	ALH	ARH
1	12	1.2	6.8	1.2	21	7.3	13	5.3
2	19	5.4	6.3	ND	27	7.0	25	7.8
3	8.2	0.90	7.4	ND	21	4.7	24	6.2
4	5.1	2.1	5.2	ND	34	6.7	31	7.2
5	9.0	1.2	6.0	0.52	40	5.6	31	9.5
Sum, Σx =	53.3	10.8	31.7	1.72	143	31.3	124	36.0
Mean $\bar{X}$ =	10.6	2.16	6.34	0.86	28.6	6.26	24.8	7.200
Sum of squared data,								
Σx^2=	679.2	37.2	203.7	171	4367	200.6	3292	269.4
CSS =	111.0	13.93	2.75	0.23	216.8	4.69	13.93	10.26
Variance =	27.76	3.48	0.688	0.231	69.30	1.173	54.20	2.56

ND = Not detected.

C (ALH) = 69.3/151.9 = 0.456 Chi square (4, 4) = 0.6284

Since calculated C is less than tabulated chi square, variances are homogenous, log transformation unnecessary.

C (ARH) = 3.48/7.44 = 0.467 Chi square (4, 4) = 0.6284

Since calculated C is less than tabulated Chi square, variances are homogenous and transformation is unnecessary.

Table 39. Analysis of variance of aliphatic petroleum hydrocarbon accumulation in lugworms in the Gulfport study.

Analysis of Variance Procedure

Dependent Variable: Weight

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	1738.95	579.65	15.26	0.0001
Error	16	607.82	37.98		
Corrected Total	19	2346.7			

C.V.	Root MSE	PPM Mean
35.020	6.163	17.60

Table 40. Analysis of variance of aromatic petroleum hydrocarbon accumulation in lugworms in the Gulfport study.

Analysis of Variance Procedure

Dependent Variable: Weight

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	105.166	35.055	15.65	0.0001
Error	13	29.11	2.239		
Corrected Total	16	134.28			
		C.V.	Root MSE		PPM Mean
		31.87	1.496		4.695

Table 41. Student-Newmann-Keuls multiple-range test of aliphatic petroleum hydrocarbon residues in samples of lugworms used in the Gulfport study.

$$S_{\bar{x}} = \sqrt{\frac{MSE}{n}} = \sqrt{\frac{37.98}{5}} = 2.75$$

At the alpha = 0.05 level,

	K	
	2	3
Q	3.00	3.65
$S_{\bar{x}}$	2.75	2.75
LSR = $QS_{\bar{x}}$	8.25	10.03

Treatment means from computer printout

Site 1	Ref	Site 3	Site 2
6.34	10.6	24.8	28.6

Mean Comparison

K	LSR	Difference between means
2	8.25	Site 3-Ref = 24.8 - 10.6 = 14.2*
3	10.03	Site 2-Ref = 28.6 - 10.6 = 18.0*

* indicates significant difference at alpha = 0.05

Table 42. Student-Newmann-Keuls multiple-range test of aromatic petroleum hydrocarbon residues in samples of lugworms used in the Gulfport study.

$$S_{\bar{x}} = \sqrt{\frac{MSE}{n}} = \sqrt{\frac{2.239}{5}} = 0.6691$$

At the alpha = 0.05 level,

	K 2	K 3
Q	3.00	3.65
$S_{\bar{x}}$	0.6691	0.6691
LSR = $QS_{\bar{x}}$	2.00	2.442

Treatment means from computer printout

Site 1	Ref	Site 2	Site 3
0.86	2.16	6.26	7.20

Mean Comparison

K	LSR	Difference between means
2	2.00	Site 2-Ref = 6.26 - 2.16 = 4.10*
3	2.44	Site 3-Ref = 7.20 - 2.16 = 5.04*

* indicates significant difference at alpha = 0.05

SECTION D-5

CULTURAL RESOURCES REPORT

DEPARTMENT OF THE ARMY
MOBILE DISTRICT, CORPS OF ENGINEERS
P.O. BOX 2288
MOBILE, ALABAMA 36628-0001

MAY 23 1988

May 17, 1988

REPLY TO
ATTENTION OF:

Environmental Resources
Planning Section

RECEIVED
MAY 20 1988
Department of Archives & History

Mr. Elbert R. Hilliard
Mississippi State Historic
Preservation Officer
Department of Archives and History
Post Office Box 571
Jackson, Mississippi 39205

Dear Mr. Hilliard:

The Mobile District, United States Army Corps of Engineers is considering improvements to the existing Federally authorized Gulfport Harbor, Mississippi navigation channel. The improvements under consideration include deepening and widening the existing channel from the Gulf of Mexico through Mississippi Sound for a distance of approximately 20 miles. In addition, realignment of the existing channel through Ship Island Pass is being studied.

In order to insure that significant submerged historic properties will not be affected by this action, underwater remote sensing surveys of the six alternate channel alignments in the vicinity of Ship Island were conducted by Mobile District personnel. A copy of the report entitled "Underwater Remote Sensing Survey, Vicinity of Ship Island, Gulfport Harbor, Mississippi" is enclosed for your review.

As is discussed in the report, twenty of the magnetic anomalies recorded during the survey have been recommended for additional evaluation. These anomalies are located along five of the alternate channel alignments (A, B, BB, C, and D). Should one of these new channel alignments be selected for inclusion in the proposed improvements to Gulfport Harbor, identification and evaluation studies would be conducted prior to dredging.

If you agree with the findings presented in this report, please sign this letter in the space provided below and return it to me within thirty (30) days. Should you require additional information, please contact Ms. Dottie Gibbens at 205/694-4114.

Sincerely,

N. D. McClure IV
Chief, Environment and Resources
Branch

Enclosure

CONCURRENCE:

5-26-88
Elbert R. Hilliard (date)
Mississippi State Historic
Preservation Officer

DEPARTMENT OF THE ARMY
MOBILE DISTRICT, CORPS OF ENGINEERS
P.O. BOX 2288
MOBILE, ALABAMA 36628-0001

May 17, 1988

MAY 1988 RECEIVED

REPLY TO
ATTENTION OF:

Environmental Resources
Planning Section

Mr. John E. Ehrenhard
Chief, Archeological Services
Branch
National Park Service
Richard B. Russell Federal Building
75 Spring Street, Southwest
Atlanta, Georgia 30303

Dear Mr. Ehrenhard:

The Mobile District, United States Army Corps of Engineers is considering improvements to the existing Federally authorized Gulfport Harbor, Mississippi navigation channel. The improvements under consideration include deepening and widening the existing channel from the Gulf of Mexico through Mississippi Sound for a distance of approximately 20 miles. In addition, realignment of the existing channel through Ship Island Pass is being studied.

In order to insure that significant submerged historic properties will not be affected by this action, underwater remote sensing surveys of the six alternate channel alignments in the vicinity of Ship Island were conducted by Mobile District personnel. A copy of the report entitled "Underwater Remote Sensing Survey, Vicinity of Ship Island, Gulfport Harbor, Mississippi" is enclosed for your review.

As is discussed in the report, twenty of the magnetic anomalies recorded during the survey have been recommended for additional evaluation. These anomalies are located along five of the alternate channel alignments (A, B, BB, C, and D). Should one of these new channel alignments be selected for inclusion in the proposed improvements to Gulfport Harbor, identification and evaluation studies would be conducted prior to dredging.

If you agree with the findings presented in this report, please sign this letter in the space provided below and return it to me within thirty (30) days. Should you require additional information, please contact Ms. Dottie Gibbens at 205/694-4114.

Sincerely,

N. D. McClure IV
Chief, Environment and Resources
Branch

Enclosure

CONCURRENCE:

5/26/85
John E. Ehrenhard (date)
Chief, Archeological Services
Branch

UNDERWATER REMOTE SENSING SURVEY

Vicinity of Ship Island

Gulfport Harbor, Mississippi

Report Prepared By: Mobile District
U.S. Army
Corps of Engineers

May, 1988

UNDERWATER REMOTE SENSING SURVEY

Vicinity of Ship Island

GULFPORT HARBOR, MISSISSIPPI

I. INTRODUCTION.

The Mobile District, U.S. Army Corps of Engineers, is considering the need for improvements to the federally authorized channel at Gulfport Harbor, Mississippi. Specifically the improvements under consideration at this time include widening and deepening of the existing channel from the Gulf of Mexico through Mississippi Sound for a total distance of approximately 20 miles. Initially, four new alternate channel alignments (A, B, C, and D) from the Gulf of Mexico through Ship Island Pass into Mississippi Sound were being considered. However, as a result of the underwater surveys conducted in September 1987 and February/March 1988, it was determined that alignments A and B crossed a submerged 20 inch pipeline. Two new alignments designated BB and E were developed for consideration. For purposes of the underwater survey alternate channel alignment D was divided into two survey sections designated D and DD. The existing channel north of Ship Island was designated Section F. The project location is shown on the Site Map and Sheet 1.

II. AUTHORITY.

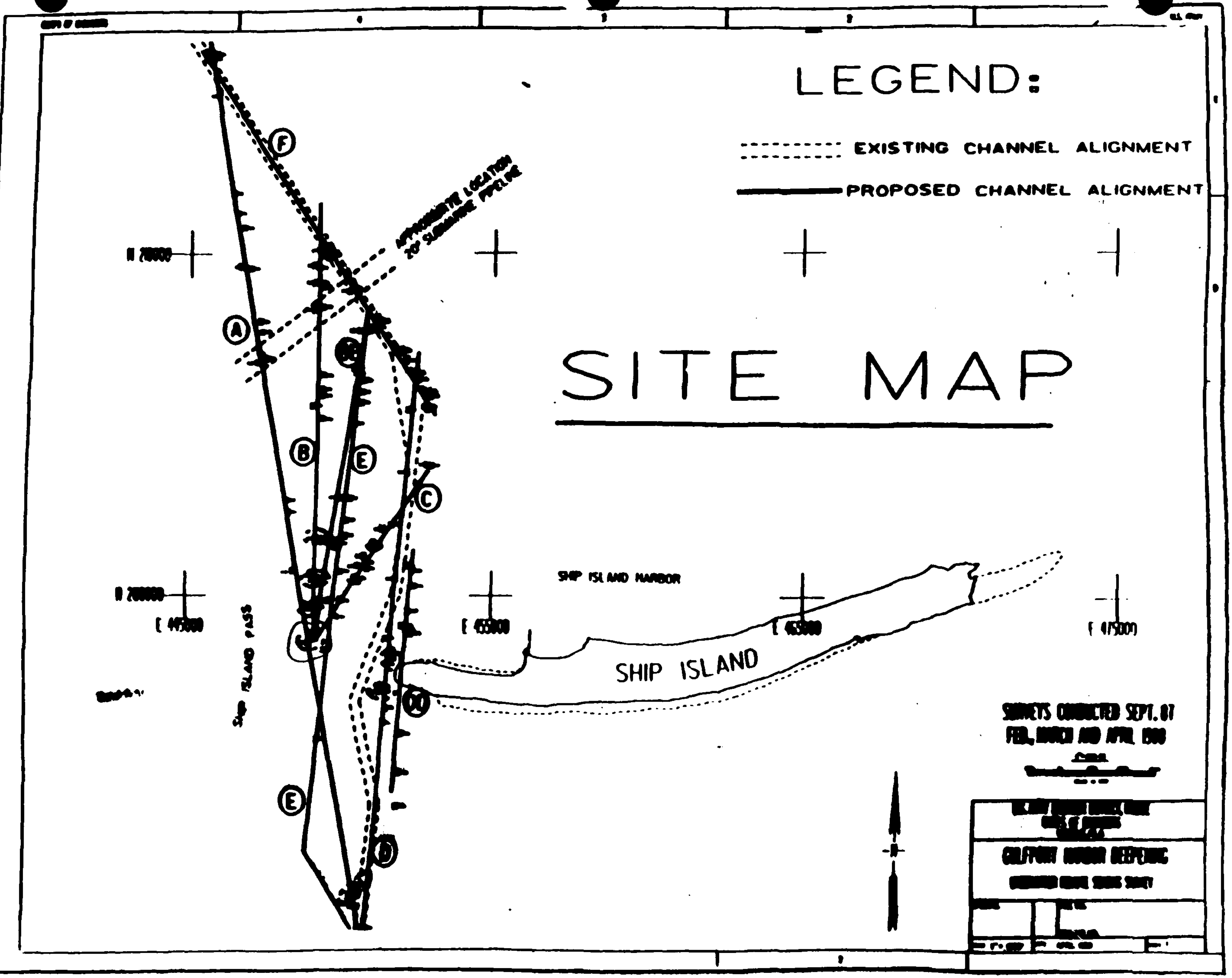
Under several historic preservation laws and Executive Order 11593, dated 13 May 1971, the Mobile District, U.S. Army Corps of Engineers has the responsibility to identify and preserve cultural resources, or mitigate losses thereto, on lands under their jurisdiction or affected by their actions.

The pertinent authorities for this responsibility include the Antiquities Act of 1906, the Historic Sites Act of 1935, The National Historic Preservation Act of 1966, as amended by the National Historic Preservation Act amendments of 1980, the Reservoir Salvage Act of 1960 as amended by the Archeological and Historic Preservation Act of 1974, Executive Order 11593, and the National Environmental Policy Act.

In compliance with these laws and Executive Order, underwater remote sensing surveys were conducted in the vicinity of Ship Island, Mississippi during September, 1987, continued in February and March 1988, and completed in April, 1988.

III. LITERATURE AND RECORDS SEARCH.

In 1987, the Mobile District contracted with OSM Archeological Consultants, Inc. to conduct documentary research to determine the potential for submerged historic properties that could be affected by proposed improvements to the Gulfport Harbor navigation channel (Mistovich, T.S., 1987). As a result of this research, it was determined that with the exception of the channel in the vicinity of Ship Island, there was little potential for submerged historic properties along the remainder of the channel. The report of the documentary research was filed with the Mississippi State Historic Preservation Officer who concurred with the recommendations that underwater remote sensing survey were necessary only in the Ship Island vicinity.



LEGEND:
EXISTING CHANNEL ALIGNMENT
PROPOSED CHANNEL ALIGNMENT
SITE MAP
SHIP ISLAND
SHIP ISLAND HARBOR
SHIP ISLAND PASS
APPROXIMATE LOCATION 20" SUBMARINE PIPELINE
A
B
C
D
E
F
E 455000
E 465000
GULFPORT HARBOR DEEPENING

Mistovich reported 9 shipwrecks for the Ship Island/Cat Island vicinity. Table 1 is a list of these vessels.

IV. PREVIOUS INVESTIGATIONS.

In October, 1986, Mobile District personnel conducted an underwater remote sensing survey of the Gulfport channel between Channel Beacons 74 and 76 approximately 2 miles south of the Harbor entrance. A proposed open water disposal area adjacent to the channel was also surveyed at that time. No evidence of submerged historic properties was recorded during that survey. The report was filed with the Mississippi State Historic Preservation who concurred with the negative report.

With the exception of this survey and the documentary research conducted by OSM Archeological Consultants, no other underwater studies have been completed for the Gulfport vicinity.

V. SURVEY METHODOLOGY

The underwater cultural resources survey of the Gulfport Harbor Channel in the vicinity of Ship Island was conducted by personnel from the Mobile District, U.S. Army Corps of Engineers. The seven person survey party included a boat operator, deck hand, survey party chief (positioning system/computer operator), two surveyors who established transponders stations for the electronic positioning system, a marine survey archeologist operating the magnetometer and an engineering technician operating the side scan sonar. The surveys were initiated in September, 1987. Survey of two of the alternate channel alignments (Sections B and C) and the existing channel north of Ship Island (Section F) was completed at that time. Survey of Sections A, C,D and DD was initiated on 26 February 1988 and completed on 1 March 1988. Survey of Sections BB and E commenced on 16 April and was completed on 17 April, 1988. A total of fifty six (56) miles of survey lines were run.

The Mobile District's 65 foot survey vessel, GATLIN, was used for the survey. Equipment array employed throughout the surveys included:

Geometrics 806-M Marine magnetometer with G801 marine sensor and Soltec Dual channel strip chart recorder

Klein Model 531 side scan sonar with 500 Khz sensor

Innerspace Model 440 Depth Sounder

Del Norte 520 Trisponder

Cubic Western DM 43 Autotape Positioning System

Grid Compass II 1129 Computer

The positioning antenna is mounted atop the vessel's mast. All the recording equipment is mounted in the vessel's cabin. The magnetometer sensor was towed 80 feet aft of the vessel. The side scan sensor was deployed off the starboard side of the vessel, and the setback for the sensors from the positioning antenna noted. All appropriate offsets were

Table 1

Shipwrecks in the Ship Island Survey Area

The EDWARD E. BARRETT, A 69 ton schooner built in 1883 and stranded on Ship Island on July 5, 1916.

The EMERALD, a 419 ton side wheel steamer built in 1859 and snagged at Cat Island on January 5, 1868, with three lives lost.

The FLOURINE, a 386 ton bark built in 1881 and stranded on Cat Island on September 17, 1906.

The FRED W. AYER, a 387 ton schooner built in 1903 and stranded on Ship Island on September 22, 1920.

The GALVESTON, a 545 ton sidewheel steamer built in 1845 and stranded on Ship Island on November 25, 1851.

The MARY G. DANTZLER, a 490 ton schooner built in 1915, which foundered off Ship Island on July 5, 1916, with all lives (8) lost.

The WILLIAM C. YOUNG, a 199 ton sidewheel steamer built in 1854, which foundered at Ship Island on August 15, 1860 with seven lives lost.

The RED CHIEF, a steamer (?), which foundered in Ship Island Pass on June 4, 1866.

The MIST, a steamer (?) built in 1863, which was lost at Ship Island on an unknown date.

SOURCE: Mistovich, Tim S. 1987 Documentary Research, Submerged Cultural Resources in the Vicinity of Gulfport Mississippi. OSM Archeological Consultants, Inc Moundville, AL.

applied for the above sensors in the interpretative processing of the data. Vessel speed varied from 2 to 3 knots dependent on tides and currents.

The proton precession magnetometer utilizes the precession (rotation) of spinning protons (hydrogen nucleii) to measure total magnetic field intensity. The precession rate of the protons is directly proportional to the magnetic field and generates a characteristic frequency. In the presence of a magnetized mass (iron or steel), the magnetometer through the sensor head, measures the subsequent change in the earth's magnetic field. This change is revealed in the digital and/or analog readout of the magnetometer, indicating the presence and amplitude in gammas of an anomaly (ferrous mass).

The side scan sonar is used to examine seafloor topography, to identify obstacles and in the search mode. The side scan sonar tow fish contains transmitting circuitry to energize transducers which project high intensity, high frequency bursts of energy (sound) in fan-shaped beams which are narrow in the horizontal plane and wide in the vertical plane. These sound beams project along the seabed, bay bottom/river bottom on both sides of the moving vessel. Objects or topographic features on the bottom surface produce echoes which are received by the transducers. The graphic recorder processes the incoming echoes and prints them on a special multi-channel writing mechanism.

Operation of these two underwater remote sensing systems, in concert, greatly enhances the quantity and quality of data obtained. The magnetometer will detect objects containing ferrous components, while the side scan sonar records any object protruding above the surface of the bottom. Thus, it is possible to immediately delineate potentially culturally significant targets and run additional survey lines to acquire more precise data for suspect targets, if needed. In addition, when the survey data is analyzed and plotted on the navigation post plot charts, it is often possible to eliminate many anomalies for further consideration since these targets are obviously created by modern debris (cable, pipe, anchor chain, buoys, trees, etc.).

Throughout the surveys, the magnetometer was set at 100 mv, with a sampling rate of 1 gamma per second. The Soltec dual channel recorder was set at a chart speed of 4 centimeters per minute, recording simultaneously on the 100 and 1000 gamma scales. Ambient magnetic field during the September 1987 surveys varied from 50512 - 50535 gammas and between 50473 - 50516 during the February - March 1988 surveys. Ambient magnetic field varied from 50445 gammas to 50463 gammas during the April, 1988 surveys. A 500 Khz sensor was used for the side scan sonar throughout the surveys. Coverage to either side of the side scan sensor was set at 50 meters.

As noted previously, the survey area included the six alternate channel alignments (Sections A, B, BB, C, D, and E), and the existing channel north of Ship Island (Section F).

Prior to the start of the survey, a survey grid was established for each of the six areas listed above on the Grid Compass II computer thus allowing the boat operator to maintain a true course down each line.

Survey lines were spaced at 150 feet intervals. Three survey lines (centerline of channel and an offset 150 feet to either side were run for each of the alternate alignments and the existing channel north of Ship Island. Throughout the surveys position fixes were noted simultaneously on all records at 200 feet intervals.

VI. SURVEY RESULTS

A total of one hundred eighteen (118) magnetic anomalies were recorded during the survey. The majority of the anomalies could not be correlated with side scan sonar targets. The extremely soft, silty condition of the seafloor in the survey area causes poor quality data acquisition from the side scan. Objects are much more likely to be buried in the seafloor in this type of environment and would be obscured from the side scan. In addition the ongoing westward migration of Ship Island adds to the likelihood of objects being buried. Table 2 is a listing of the anomalies and side scan targets for each of the survey areas. As is indicated in this table, those side scan targets that could be correlated with the magnetometer data do not appear to represent culturally significant material.

Eight of the highest amplitude magnetic targets have been eliminated from further consideration in that they fall within a pipeline corridor. These targets include anomalies A-1-2, A-2-3, A-3-6, B-1-3, B-2-4, B-3-2, F-1-3,and F-2-2. As can be seen on Sheet 1, high amplitude magnetic readings were recorded on the parallel survey lines on each of the three channel alignments that cross the pipeline corridor. Each of these targets produced sharp dipolar readings which are typical of the magnetic signatures of pipelines.

Similarly, none of the targets that were recorded within and immediately adjacent to the existing channel are believed to warrant further consideration. The majority of the these anomalies produced magnetic values of less than 50 gammas. The post plot of the anomalies illustrated on Sheet 1 did not reveal any evidence of "clustering" that can be indicative of scattered wreck debris. Finally, the likelihood of encountering significant shipwreck remains in a channel that has been repeatedly dredged since 1899 is extremely remote.

A total of twenty (20) of the anomalies do appear to warrant further evaluation. They were selected on the basis of high magnetic values or proximity to other, possibly associated, anomalies. In some instances, the side scan sonar imagery revealed unidentified partially buried debris or unusual bottom relief associated with the magnetic targets. The targets selected include anomalies A-1-4, A-2-8, A-3-7, B-1-5, B-2-1, B-2-2, B-2-3, B-3-7, B-3-8, BB-1-1, BB-1-2, BB-1-3, C-1-6, C-2-4, C-1-3, D-1-3, D-2-4, D-3-1, D-3-2 and D-2-5. These anomalies are circled on Sheet 1. Table 3 lists the coordinates of the anomalies.

The remaining magnetic anomalies recorded during the survey were low amplitude isolated targets indicative of single objects. No further consideration of these anomalies is recommended.

Table 2

Survey Line	Shot Point	Anomaly #	Gammas	Side Scan Target
Section A Line 1	34-35	A-1-1	9	----
	49	A-1-2	240	----
	80	A-1-3	12	----
	127-129	A-1-4	60-240 series	----
	130	A-1-5	8	----
Line 2	285	A-2-1	11	----
	286-287	A-2-2	10	----
	304-305	A-2-3	160	----
	322	A-2-4	8	----
	325	A-2-5	11	----
	337	A-2-6	10	----
	341	A-2-7	13	----
	389-391	A-2-8	700	----
Line 3	145	A-3-1	19	----
	171	A-3-2	20	----
	177	A-3-3	80	----
	185	A-3-4	27	----
	186-187	A-3-5	25	----
	190-191	A-3-6	220	----
	356-357	A-3-7	45	----
	363	A-3-8	18	----

Table 2

Survey Line	Shot Point	Anomaly #	Gammas	Side Scan Target
Section B Line 1	10-11	B-1-1	6	small unidentified target
	13	B-1-2	11	----
	17-18	B-1-3	280	small partially buried targets (pipe?)
	31	B-1-4	16	----
	60	B-1-5	24	large depression in bottom
Line 2	71-72	B-2-1	27	disturbed bottom unidentified target
	76	B-2-2	17	----
	82	B-2-3	320	----
	113-117	B-2-4	460 - 700 series	----
	119	B-2-5	11	small target
	121	B-2-6	12	----
	123-124	B-2-7	9	----
Line 3	143	B-3-1	45	----
	146-147	B-3-2	680	----
	156-157	B-3-3	56	----
	158-159	B-3-4	6-8	----
	159-160	B-3-5	19	mounded area on bottom

Table 2

Survey Line	Shot Point	Anomaly #	Gammas	Side Scan Target
Section B Line 3	163	B-3-6	25	----
	180-181	B-3-7	110	----
	186	B-3-8	66	cable
	188	B-3-9	9	----
Section BB Line 1	33	BB-1-1	9	----
	38-39	BB-1-2	17	rectangular 25'x10' target
	42-43	BB-1-3	11	----
	116	BB-1-4	11	30' linear target
	120-121	BB-1-5	55	----
Line 2	71-72	BB-2-1	9	----
Line 3	6	BB-3-1	10	small rectangular target
	13	BB-3-2	41	sand waves
	93-94	BB-3-3	15	----
Section C Line 1	1	C-1-1	20	----
	13	C-1-2	25	----
	15-16	C-1-3	820	----
	18	C-1-4	19	----
	19-20	C-1-5	10-26 series	----
	33	C-1-6	110	----
Line 2	1	C-2-1	28	----

Table 2

Survey Line	Shot Point	Anomaly #	Gammas	Side Scan Target
Section C				
Line 3	11-12	C-2-2	34	----
	18-19	C-2-3	37	----
	21	C-2-4	730	----
	25	C-2-5	15	----
Line 3	47	C-3-1	13	----
Section D				
Line 1	418	D-1-1	9	----
	449	D-1-2	10	----
	457-458	D-1-3	11	----
Line 2	510	D-2-1	17	----
	539-540	D-2-2	25	----
	542-543	D-2-3	21	----
	543	D-2-4	440	----
	550-551	D-2-5	42	----
Line 3	659	D-3-1	80	----
	659-660	D-3-2	29	----
	666-667	D-3-3	9	sand waves
	678	D-3-4	9	----
	689-690	D-3-5	9	----
Section DD				
Line 1	694-695	DD-1-1	45	----
	701-702	DD-1-2	31	----
Line 2	707	DD-2-1	12	----

Table 2

Survey Line	Shot Point	Anomaly #	Gammas	Side Scan Target
Section DD Line 2				
	709	DD-2-2	13	----
	714	DD-2-3	9	----
Line 3	649-650	DD-3-1	6	----
	654	DD-3-2	5	----
	657-658	DD-3-3	5	----
	720-721	DD-3-4	7	----
	726	DD-3-5	11	----
Section E Line 1	29	E-1-1	17	narrow linear target
	36-37	E-1-2	10	----
	44	E-1-3	7	----
	51	E-1-4	10	small unidentified target
	172-173	E-1-5	68	----
Line 2	127	E-2-1	13	----
	154	E-2-2	10	----
	196	E-2-3	10	----
Line 3	59	E-3-1	68	----
	62-63	E-3-2	15	----
	64-65	E-3-3	82	----
	70	E-3-4	34	----
	76-77	E-3-5	55	----
	188-189	E-3-6	110	----
	190	E-3-7	140	----
	191	E-3-8	40	----

Table 2

Survey Line	Shot Point	Anomaly #	Gammas	Side Scan Target
Section F Line 1	36	F-1-1	47	----
	37-38	F-1-2	16	----
	43-44	F-1-3	70	----
	63	F-1-4	32	----
Line 2	66-67	F-2-1	25	----
	86-87	F-2-2	220	----
	92	F-2-3	24	small target
Section F Line 3	129-130	F-3-1	12	----
	130-131	F-3-2	45	----
	173	F-3-3	30	----
	177-178	F-3-4	51	----
	178-179	F-3-5	8	----
	181	F-3-6	26	----
	182	F-3-7	13	----
	184	F-3-8	85	----
	184-185	F-3-9	27	----

Table 3

Anomaly Number	Northing	Easting
A-1-4	191,298.0	450,477.0
A-2-8	191,395.0	450,583.0
A-3-7	191,582.0	450,691.0
B-1-5	199,616.0	449,061.0
B-2-1	199,623.0	449,238.0
B-2-2	200,598.0	449,224.0
B-2-3	201,642.0	449,237.0
B-3-7	201,639.0	449,367.0
B-3-8	200,511.0	449,360.0
BB-1-1	198,602.0	449,029.0
BB-1-2	199,713.0	449,222.0
BB-1-3	200,425.0	449,361.0
C-1-3	201,442.0	451,075.0
C-1-6	198,678.0	449,237.0
C-2-4	200,445.0	450,555.0
D-1-3	197,201.0	451,389.0
D-2-4	197,226.0	451,420.0
D-2-5	198,299.0	451,731.0
D-3-1	198,014.0	451,642.0
D-3-2	198,160.0	451,674.0

Mississippi Department of Archives and History

Post Office Box 571 • Jackson, Mississippi 39205-0571 • Telephone 601-359-1424
Elbert R. Hilliard, Director

April 14, 1987

Mr. N. D. McClure, IV
Chief, Environment and Resources Branch
Corps of Engineers, Mobile District
P. O. Box 2288
Mobile, AL 36628-0001

RE: Documentary Research, Submerged Cultural Resources in the vicinity of Gulfport, Mississippi by Tim S. Mistovich, March 23, 1987 (87-058)

Dear Mr. McClure:

We have reviewed the above research document, submitted to this office on April 2, 1987. We concur with the assessments regarding the need for additional investigations. Thank your for allowing us this opportunity to comment.

Sincerely,

ELBERT R. HILLIARD
State Historic Preservation Officer

Roger G. Walker

By: Roger G. Walker
Interagency Coordinator

RGW/am

cc: Clearinghouse for Federal Programs

United States Department of the Interior

NATIONAL PARK SERVICE
SOUTHEAST REGIONAL OFFICE
75 Spring Street, S.W.
Atlanta, Georgia 30303

IN REPLY REFER TO:

April 28, 1987

Mr. N. D. McClure, IV
Chief, Environment and Resources Branch
Mobile District, Corps of Engineers
P.O. Box 2288
Mobile, Alabama 36628-0001

Re: Report Review-"Documentary research, Submerged Cultural Resources In The Vicinity of Gulfport, Mississippi" prepared by OSM Archaeological Consultants, Inc.

Dear Mr. McClure:

We have reviewed the referenced report and offer the following comments for your consideration.

The draft fulfills the requirements of the Scope of Work and we have no criticisms of the investigations and interpretations. However, we suggest that the quality of the maps could be improved. Many lack a legend and some others have been reduced to such a degree that the printing is illegible. Editorial corrections, exclusions, and typographical errors are noted in the draft.

Should you have any questions concerning this review, please contact Ms Patricia Fay at FTS 242-2629 or Commercial 404-331-2629.

Sincerely,

John E. Ehrenhard

John E. Ehrenhard
Chief, Archeological Services Division

Enclosure

SADPD-R (1105-2-10c)(SAMPD-ER/3 Apr 87) 1st End Mr.Rucker/mh/FTS 242-6043
SUBJECT: Transmittal of Draft Report: Documentary Research, Submerged Cultural Resources in the Vicinity of Gulfport, Mississippi

DA, South Atlantic Division, Corps of Engineers, 510 Title Building, 30 Pryor Street, S.W., Atlanta, GA 30335-6801 20 April 1987

TO: Commander, Mobile District, ATTN: SAMPD-ER

As requested, we have reviewed subject report and have no comment.

FOR THE COMMANDER:

John W Rushing

JOHN W. RUSHING
Acting Chief, Planning Division

Encl
nc

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COESAM/PDER-87-005

DOCUMENTARY RESEARCH, SUBMERGED CULTURAL RESOURCES IN THE VICINITY OF GULFPORT, MISSISSIPPI

Tim S. Mistovich

Submitted to the
U.S. Army Corps of Engineers,
Mobile District

under the provisions of
Contract No. DACW01-87-M-3058

OSM Archaeological Consultants, Inc.
P.O. Box 401
Moundville, Alabama 35474

June, 1987

ABSTRACT

U.S. Army Corps of Engineers studies for navigation improvements at Gulfport, Mississippi, include a consideration of cultural resources. A documentary research program was conducted to ascertain the potential for submerged cultural resources within the project area. This document presents the historical background, history of navigation improvements, and shipwreck compilation for the study area. It is concluded that there is sufficient potential for adverse impact to significant submerged resources within the Ship Island segment of the project to warrant additional investigations.

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I

INTRODUCTION

A short distance from the south coast of Mississippi lies a unique natural harbor in the otherwise shallow waters of the Mississippi Sound. For over three centuries, ships' captains have used the anchorage at Ship Island as a staging point for exploration, settlement and trade. Less than a century ago, the City of Gulfport was established on the coast to the north of the island, providing a railroad link to the interior during the timber boom years at the turn of the century. The success of Gulfport, then as now, hinged on the development and maintenance of a navigable ship channel between the town and the Ship Island harbor. Gulfport's partner in the construction and improvement of the channel for nearly a century has been the U.S. Army Corps of Engineers (USCOE), which is currently considering new modifications in the form of channel deepening and widening. Prior to such work, the potential impact to cultural resources within the study area (Figure 1) must be considered. Consequently, USCOE, Mobile District commissioned OSM Archaeological Consultants, Inc. to conduct historic research to assess the potential for significant cultural resources and provide recommendations for any additional investigations which might be required.

This document presents the results of the historic research conducted. As the potential project impact will occur within the waters of the Mississippi Sound, the emphasis of the research is on the maritime history of the area. The following section attempts to place both Gulfport and Ship Island within the context of coastal Mississippi maritime development. It is succeeded by a discussion of navigation improvements performed over the last century. Finally, a compilation of recorded vessel losses in the study area is presented, along with a statement of potential impact to submerged cultural resources and recommendations for further investigations.

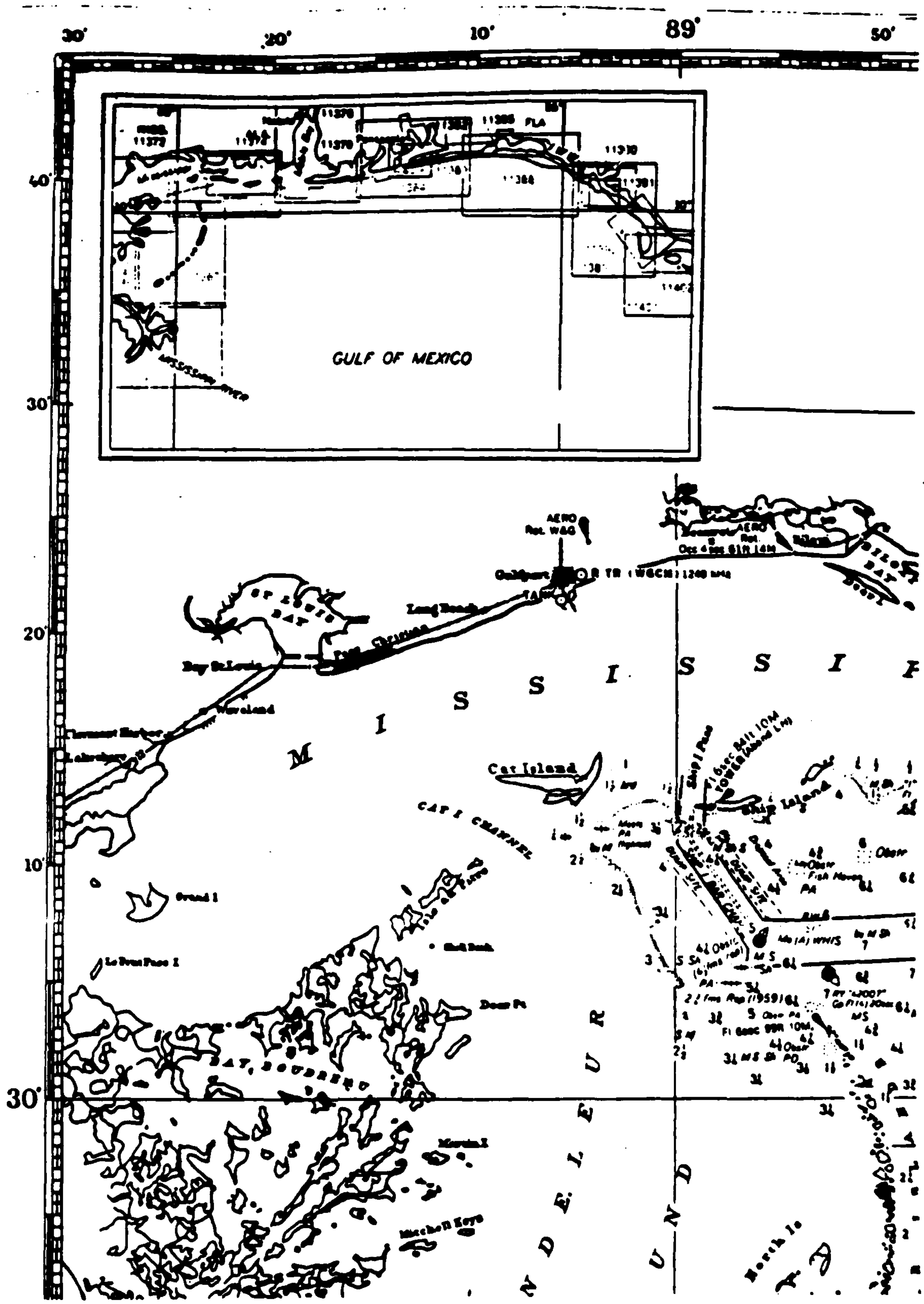

Figure 1. Study Area.

The bulk of the research in this effort was conducted during February, 1987. A variety of sources were consulted in an effort to provide a comprehensive overview. Previous studies of a similar nature along the northern Gulf Coast provided the structural framework for this research (Coastal Environments 1978, Mistovich and Knight 1983, Mistovich, Knight, and Solis 1983, Mistovich 1987). Much of the primary data was contained within regional repositories: the USCOE Mobile District Technical Library, Mobile Public Library, Harrison County, Mississippi Library, and the Mississippi Department of Archives and History (MDAH), Jackson. Interviews with persons knowledgeable in the maritime activities of the area were conducted. Of particular value was the information provided in this manner by historian M. James Stevens of Biloxi, Mississippi, Captain John Foretich of Gulfport, and Bill Paulus and Carey Ingram of the U.S. Naval Oceanographic Office at Bay St. Louis.

The assistance of the various personnel at these institutions was instrumental to the conduct of this research. Special acknowledgement is due Sam McGahey and Mike Hammack of MDAH, Jackson and Sissy Scott and Mary Gordon of the Technical Library at USCOE, Mobile. Finally, Dorothy Gibbens, USCOE, Mobile archaeologist and project monitor, deserves our appreciation for her guidance over the course of this work.

Tim Mistovich
Marine Archaeologist
OSM, Inc.

Carey B. Oakley
Principal Investigator
OSM, Inc.

II

HISTORICAL BACKGROUND

Gulfport is a relative newcomer to the Mississippi coast, with a history spanning little more than a century. The origins of the city are linked to the visions of a southern railroad baron and a northern entrepreneur, the vast timber resources of late 19th century coastal Mississippi, and the unique natural harbor present at a small barrier island eleven miles offshore.

The Gulf and Ship Island Railroad had held a charter to build a road from Jackson to the Gulf Coast for thirty years when William H. Hardy assumed control of the company in the 1880s. In retrospect, the Civil War and Reconstruction years which delayed construction may have proved beneficial. By the 1880s, the white pine forests in the northern states were exhausted and the lumber companies began acquiring vast tracts of virgin timber in southern Mississippi. Hardy's plans for the Gulf and Ship Island Railroad involved a transportation link traversing the rich woodlands and terminating on the coast at a town which he would build. From this port, the timber could be ferried to the best anchorage on the Mississippi coast, the natural harbor at Ship Island. There, sailing vessels would provide the final link to the markets of the Atlantic Coast and Europe. This system offered substantial improvements over the existing one, in which sawmills scattered along various coastal rivers and bayous floated logs to the Mississippi Sound and thence to coastal towns such as Biloxi or Pascagoula, none of which could accomodate deep draft vessels.

Hardy and his colleagues formed the Union Investment Company, which purchased land in 1884 near the small coastal town of Handsboro for $5 an acre. The town site was plotted and subdivided into lots and over 36 miles of railroad track laid from Hattiesburg south by 1886. Six years later, however, the company exhausted its funds and the project was abandoned (Lang 1936:82). The tracks were within twenty miles of the new town site.

Three years passed before a new investor was attracted. In 1895, Joseph T. Jones, a northerner who had earned millions in the pioneer oil fields of Pennsylvania, purchased the Gulf & Ship Island Railroad through his Bradford Construction Company. This infusion of new capital allowed completion of the railroad to Gulfport in 1900, one year after the town's incorporation. The effect on the regional timber industry was immediate and dramatic. In 1899, there were eighteen sawmills along the uncompleted length of the Gulf & Ship Island Railroad. By 1902, sixty mills were in place, producing 300,000,000 board feet per year. Within seven years, this output almost tripled and represented 10 percent of the yellow pine lumber in the entire South (Hickman 1973: 215).

Jones virtually poured money into the development of Gulfport. As detailed in the following chapter on navigation improvements, an intensive lobbying effort was made for federal aid in developing a channel and anchorage basin. Even with the approval of this work in 1899, Jones' company outspent the government ten to one in improving the port. The coast at Gulfport offered no natural protective harbor. Jones created one by building two long piers bracketing an anchorage area and protected on the seaward side by a timber and stone breakwater. The character of the town underwent rapid change. The Gulfport Record of July 9, 1904 reported that 26 brick commercial buildings lined the broad avenues of the downtown district. In 1902, there had been none. Resident population grew from 1,000 in 1900 to 6,000 in 1907. Jones' eventual investment in the town and port has been estimated at $16 million (Lang 1936:84).

The timber boom continued to provide the economic underpinning for south Mississippi in the early years of the twentieth century. In the period 1904-1915, Mississippi ranked third among the United States in lumber production. The highwater mark was reached in 1909, when 1,761 mills produced two billion board feet of lumber (Hickman 1973:214). Jones had brought the first seagoing vessel into Gulfport in January, 1902 by offering a guarantee against damages of $1,000 to the captain of the Italian schooner Trojan (Lang 1936:83). By 1906, Gulfport was the

largest lumber export city in the nation, shipping 293,000,000 board feet. Additional cargo in the form of naval stores, cotton and cottonseed was brought by rail from the interior and shipped from Gulfport. Two shipyards, Martinoloch and Favre, were constructed in the Gulfport area, specializing in the building of sailing vessels for the Atlantic trade.

The years of the timber boom drew to a close by the time of World War I, with the depletion of the yellow pine forests of the interior. Commercial statistics for the years 1925-1929 reveal a steady decline from 604,000 short tons to 479,000 short tons (USCOE 1929:931). By 1939, the figure had dropped to 240,000 short tons. Lumber remained the leading export product, accounting for 75 percent of trade, but the amount of board feet available had dropped significantly.

Goods imported into Gulfport were varied: asphalt from Trinidad, nitrate from Chile, bananas from the Central American republics. It was the latter product which eventually became the leading import at Gulfport. The first banana boat arrived in 1919. By the early 1960s, bananas constituted the major cargo handled at the port. Major import facilities were built at Gulfport by Standard Fruit and United Brands, transforming the city into a major banana importing terminal. Of the 1.1 million short tons of cargo handled in 1983, bananas constituted more than half the total (Jackson Clarion-Ledger, November 13, 1983).

The history of maritime development at Gulfport requires discussion of an additional component, the anchorage at Ship Island. Other than Pensacola, Ship Island provides the only natural deepwater harbor on the northern Gulf Coast. The developers of Gulfport had this fact uppermost in their minds when selecting a site for the town. The 25 to 40 ft of water depths in the protected anchorage paralleling the northern, protected side of the barrier island had proved safe haven for sea-going vessels for two centuries prior to the arrival of the developers.

Iberville's French fleet was the first to anchor there, arriving on February 10, 1699. French colonial reports called the island Ile de

Surgeres for a number of years, in honor of Comte De Surgeres, a member of the expedition. Early in the 1700s, however, the name was changed to Ile aux Vaisseaux, or Ship Island (Steckel 1975:6). It was immediately utilized as a safe anchorage for ships provisioning the first French coastal settlement at Biloxi. Cargo was lightered into the settlement by longboats. In 1704, the first "filles a la cassette" or casket girls arrived at Ship Island onboard the Pelican (Caraway 1942:78). The 1717 hurricane which destroyed the French anchorage at Dauphin Island to the east increased the strategic importance of Ship Island. The French constructed a warehouse and barracks on the island and brought in the St. Louis in 1720 to serve as a floating warehouse. The first of the German colonists under French sponsorship arrived in 1719. By 1739, twelve thousand had been brought in through the Ship Island anchorage (Steckel 1975:17). The usefulness of the island waned following the development of the port at New Orleans in 1722 and the warehouse facilities were in disuse by 1724.

Control of Ship Island passed from the French to the British in 1763. During the Revolutionary War, the British stationed a 16 gun warship at the anchorage in an effort to arrest smuggling by the colonists. The British returned during the War of 1812, anchoring a fleet of 30 warships and 30 support vessels at Ship Island on December 10, 1814 (Caraway 1942:79). From this staging area, raids were launched on New Orleans. An idea of the size of the anchorage at the island is apparent from the fact that the British 60 vessel fleet fit comfortably within the natural harbor on the western and northern sides of the island (Steckel 1975:26).

Ship Island was one of the locations chosen for a coastal defense fortification in 1856 by Secretary of War Jefferson Davis (Burns 1971). The fort was only partially finished at the outbreak of the Civil War, when it was occupied by a small party of Confederates. The garrison named the fort "Twiggs", after the commanding general at New Orleans, David E. Twiggs (not to be confused with the earlier "Camp Twiggs" on Greenwood Island near Pascagoula; see Mistovich, Knight, and Solis 1983: 33). Only one engagement was fought here during the Civil War. On July

9, 1861, the Union vessel Massachusetts beseiged the fort, firing 70 cannon balls, but failing to dislodge the garrison. By September of 1861, however, the Union blockade of the Gulf Coast forced the Confederate evacuation of Fort Twiggs. Marines from the Massachusetts occupied the fort, and it was renamed in honor of the warship. For the duration of the war, Fort Massachusetts served as a staging area for the Gulf Coast theater and a prisoner-of-war camp for captured Confederates. In April, 1865, over four thousand P.O.W.s were held here (Burns 1971:32).

Fort Massachusetts was not completed until 1871. By 1880, it was considered obsolete and essentially abandoned. In 1878, the government built a quarantine station to the east of the fort. This served as a port of entry for immigrants and an isolation station for yellow fever victims (Burns 1971:35). During these same years, the Ship Island anchorage became the main loading point for the lumber which began to stream from the interior in ever increasing quantities. The small coastal settlement of Handsboro served as the main link to the sawmills of the interior, until the building of Gulfport at the turn of the century. As Gulfport lacked deep water approaches during its early years, seagoing steamships and sailing vessels either traveled to and from Gulfport only partially loaded or anchored at Ship Island harbor and were loaded from smaller, shallow draft vessels capable of navigating the 19 ft deep channel extending the 11 miles to Gulfport. Evidence of the bustling character of the Ship Island anchorage is seen in the shipping statistics for the year 1905, during the height of the lumber boom. In that year, 84 steamships, 89 schooners, 49 barks, and 17 "ships" were loaded with 415,000 tons of cargo (USCOE 1905:1291).

Ship Island is now part of the Gulf Island National Seashore. As a barrier island, it is subject to continual, sometimes dramatic, change. The predominant southeasterly wind and wave directions in the Gulf of Mexico result in erosion on the east end of the island and accretion on the west end. Between 1860 and 1948, it is estimated that Ship Island migrated 0.72 miles westward (National Park Service 1979:22). Fort Massachusetts, which was constructed in the center of the western end of the island, is now essentially detached and surrounded by water. Final-

ly, the most dramatic change occurred during the 1969 hurricane, which cut the island in half.

A number of National Register of Historic Places (NRHP) sites in the study area are representative of this historical background. These include the 85 acre Fort Massachusetts Historic District and the 15 acre Ship Island Lighthouse District, administered under the Gulf Island National Seashore. In Gulfport, the 26 acre Harbor Square Historic District represents the city's original central business district. Separate NRHP listings in Gulfport include the U.S. Post Office and Courthouse completed in 1910, the Hewes Building, a commercial structure of the 1903-1904 era, and the antebellum Milner House, also called Grass Lawn.

III

NAVIGATION IMPROVEMENTS

The completion in 1896 of the Gulf & Ship Island Railroad from Gulfport to Hattiesburg provided the critical link between the timber rich Coastal Plain interior of Mississippi and the shipping lanes of the Mississippi Sound. One gap remained, however, in the efficient transport of timber from the interior. This was the eleven miles separating the port facilities at Gulfport and the deep water anchorage at Ship Island. Shallow water depths in this segment of the Sound meant that lumber had to be either lightered or floated the eleven miles from Gulfport to Ship Island. In addition, shallow water over the bar south of Ship Island limited the amount of lumber and agricultural products which could be taken onboard in the Ship Island anchorage. Thus, a vigorous campaign for navigation improvement was begun.

Early surveys of Ship Island Harbor (1881) and Gulfport Harbor (1889) had recommended no improvements (USCOE 1882:1321; 1889:1460). The River & Harbor Act of June 3, 1896, again authorized "preliminary" examinations to be conducted. In a letter dated October 23, 1896, W.H. Hardy wrote that the Ship Island Harbor was the "finest in the world," providing 25 to 40 ft of depth at high tide and located at the convenient midpoint between Mobile and New Orleans. Also, Hardy claimed that no sea-going ship had been lost in the harbor since its first use in "1698." In fact, eight ships in harbor during the October, 1893 hurricane had ridden out the storm relatively unscathed (USCOE 1897:276). While not disputing these claims, the preliminary examination of the area by Major William T. Rossell of the Corps of Engineers, submitted on November 19, 1896, concluded that improvements were not warranted, due to a lack of sufficient trade and the fact that the Gulf & Ship Island Railroad would be the sole beneficiary of any improvements (USCOE 1897: 1709-1710).

Those promoting the Gulfport-Ship Island improvements spent the next two years bolstering their arguments. The USCOE Annual Report of

1899 contains the justifications presented from several sources. A letter from the Mayor and Board of Aldermen dated December 6, 1898, estimates the area's daily capacity at 700,000 ft of pine lumber and states: "that owing to the want of deep water at the pier at Gulfport, this lumber must be transported on barges from the pier to ships at the great expense of $1/thousand ft, and can only be shipped on vessels coming into port light, as they cannot land to discharge their cargoes, and therefore charge lighter freights" (USCOE 1899:1798).

Pointing out the degree of maritime traffic at Ship Island, the Office of the Collector of Customs at Shieldsboro, Mississippi revealed that 155 vessels carrying 152,390 tons of freight had used the harbor during fiscal year 1897, adding that the low water at the Ship Island bar caused delays of seven to ten days and presented serious risks of grounding (USCOE 1899:1813). The Customs Office at Biloxi noted that large draft vessels could not take on a full cargo at Ship Island and pass over the bar when depths decreased to less than 27 ft at mean low tide. As a result, ships would only take on part of their cargo in the harbor, then anchor south of the bar to finish loading (USCOE 1899: 1813).

Apparently, the campaign for navigation improvement had an effect. On June 16, 1898, Congress ordered another survey to determine a plan for a 26 ft deep channel at mean low water through Ship Island Pass (H. Doc. 120, 56th Congress, 3rd Session). Major Rossell was again put in charge of the survey, to begin in July, 1898, but delayed until November of that year, "owing to threatened yellow fever" (USCOE 1899:1787). Authorization for the work was passed in the following year in the River and Harbor Act of March 3, 1899. This legislation provided for a channel 300 ft wide and 19 ft deep (at mean low water) from the anchorage at Ship Island to Gulfport, as well as the construction at the end of the channel (next to shore) an anchorage basin of similar depth and not less than 2,640 ft by 1,320 ft in area. A separate provision was made for Ship Island Pass, where a 26 ft deep channel was proposed across the bar from the inner to outer 26 ft depth curve in the Gulf of Mexico. The cost for the Gulfport channel and basin improvements was not to exceed

$150,000, with $10,000 per year appropriated for maintenance over a five year period, while $40,000 was appropriated for Ship Island Pass (USCOE 1899: 312, 1722). At the time of this act, water depths over the line of the proposed Gulfport to Ship Island channel varied from 8.9 to 17.9 ft and averaged 9 ft deep in the proposed basin area.

Work began on the Ship Island Pass channel in November, 1899. By March 13, 1900, the National Dredging Company of Wilmington, Delaware had removed 163,401 cubic yards of sand, clay and mud to form a channel 4,000 ft long, 300 ft wide and 26 ft deep from the inner to outer 26 ft contour line. Vessels of up to 25 ft draft could now consistently cross the bar (USCOE 1900:2217). Dredging of the Gulfport channel and anchorage basin was delayed until April 16, 1901 (USCOE 1902:306). The channel portion was declared complete by August, 1903 (USCOE 1904:338) and the basin by June, 1905 (USCOE 1905:349) (Figures 2 and 3). However, the 1925 Annual Report of the Chief of Engineers reveals that, due to dredging problems encountered, the maximum project dimensions were not reached until 1924. Also of note is the contribution of the Gulf & Ship Island Railroad to the harbor improvements. Certainly the major beneficiary of the improvements, it was also the major contributor, spending an estimated $1.6 million for dredging on the Gulfport channel and anchorage basin during the formative years of the project.

In the following years, the Gulfport channel/basin and Ship Island Pass projects were combined under the River & Harbor Act of March 2, 1907 (H. Doc. 184, 59th Congress, 2nd Session). The River and Harbor Act of February 27, 1911 authorized the transfer of a government dredgeboat to Gulfport for maintenance dredging in the face of rapid channel silting in the Mississippi Sound (River & Harbor Commission Document No. 2, 60th Congress, 1st Session). This continued to be a navigation problem, as evidenced in the Annual Report of 1919, wherein a request is made for additional maintenance funds in the face of channel shoaling at a rate of 2.6 million cubic yards a year (USCOE 1919:940). This followed a year when commerce into Gulfport amounted to 179,924 short tons valued at $3.6 million, 88 percent of which was lumber (USCOE 1919:941).

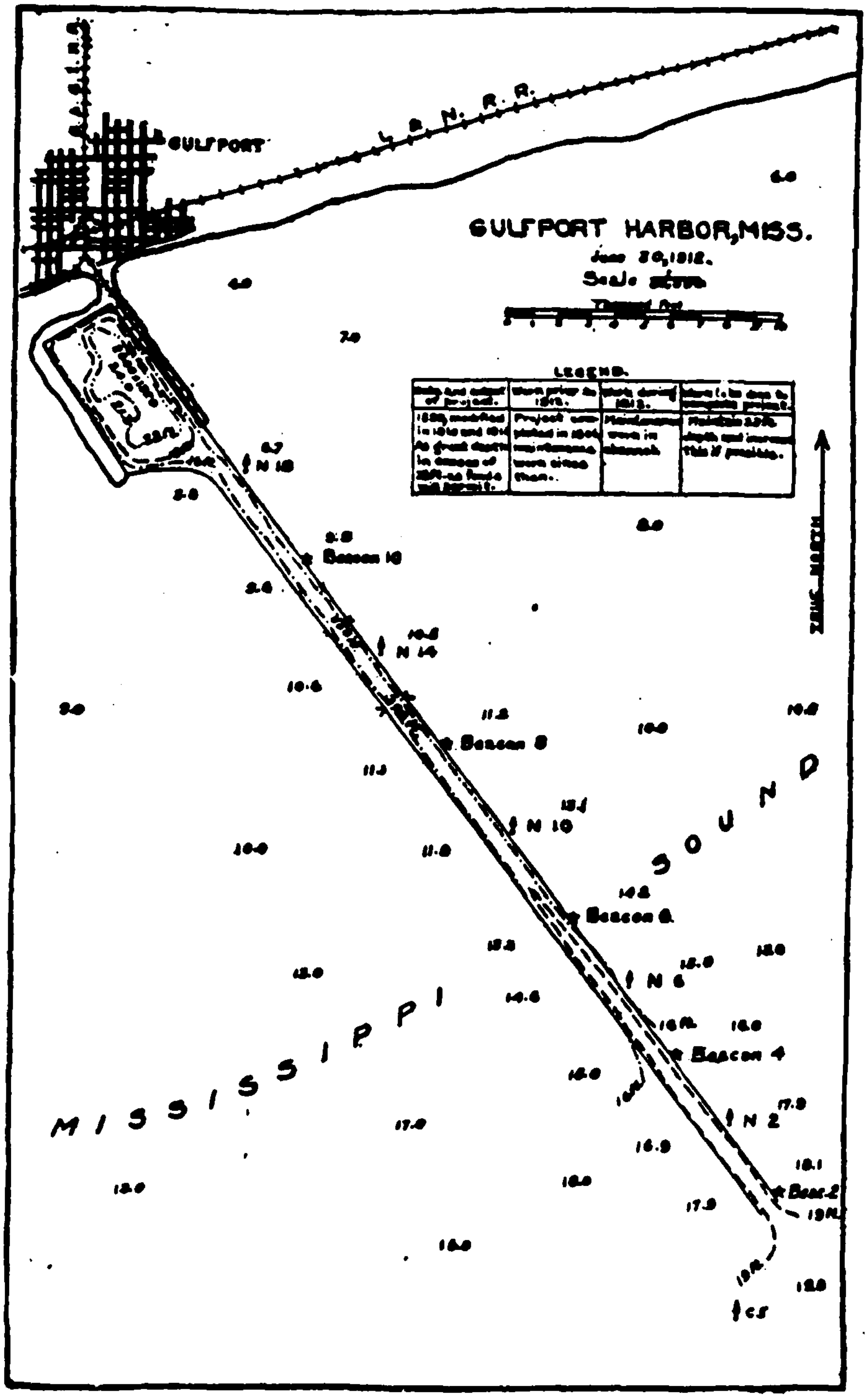

Figure 2. Gulfport Harbor in 1912 (USCOE, Mobile).

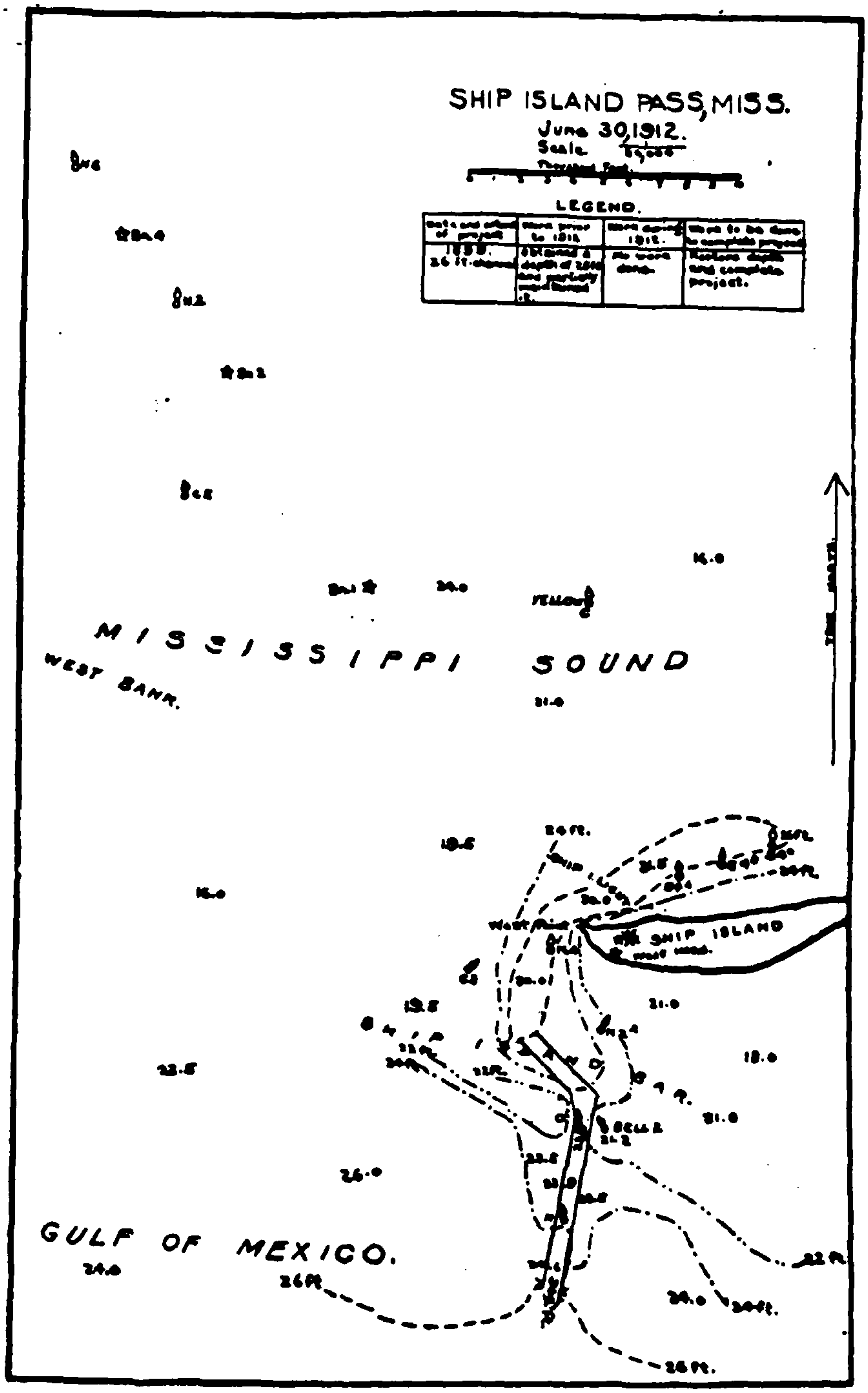

Figure 3. Ship Island Pass, 1912 (USCOE, Mobile).

In the face of rapid channel shoaling and increasingly expensive maintenance dredging, two modifications to the project were approved in the River and Harbor Act of January 21, 1927 (H. Doc. 692, 69th Congress, 2nd Session). The width of the Gulfport channel was reduced from 300 ft to 220 ft as a result of shoaling estimated at 4 million cubic yards annually. The channel across Ship Island Bar was to be relocated 5,000 ft west of the existing channel, thus providing a shorter, more direct route and avoiding hard sand deposits in the existing channel which proved difficult to dredge (Figure 4). Annual maintenance costs in 1927 had reached $185,000 (USCOE 1934:582).

The Gulfport channel depth remained at the authorized 19 ft depth at a time when ocean-going steamers were increasing in size and draft. The larger vessels were forced to either anchor at Ship Island and lighter their cargos to the docks at Gulfport or enter and leave port only partially loaded. To alleviate this condition, the River and Harbor Act of July 3, 1930 provided for a channel 27 ft deep and 300 ft wide across the Ship Island Bar, a channel 26 ft deep and 220 ft wide through the Mississippi Sound to Gulfport, and a depth of 26 ft within the anchorage basin at Gulfport. These improvements were started in 1932 and completed in 1934 at a cost of $118,000 (USCOE 1935:675).

From 1942 until early 1946, the U.S. Navy leased the port facilities at Gulfport as a transshipment point for war material. To provide for Navy vessels, the Gulfport channel was dredged "several feet" below project depth in 1944 (USCOE 1948:994). Shortly after the war, the River & Harbor Act of June 39, 1948 authorized further channel improvements. The Ship Island channel was extended to 32 ft deep and 300 ft wide over a distance of 8 miles, the Gulfport channel modified to 30 ft deep and 220 ft wide for a distance of 11 miles, and the Gulfport anchorage increased to a depth of 30 ft within a 1,320 ft wide by 2,640 ft long area (H. Doc. 112, 81st Congress, 1st Session). This work was completed in April, 1950 at a cost of $636,000 (USCOE 1950:906).

Improvements to the harbor facilities at Gulfport were historically a partnership venture of local interests and the federal government.

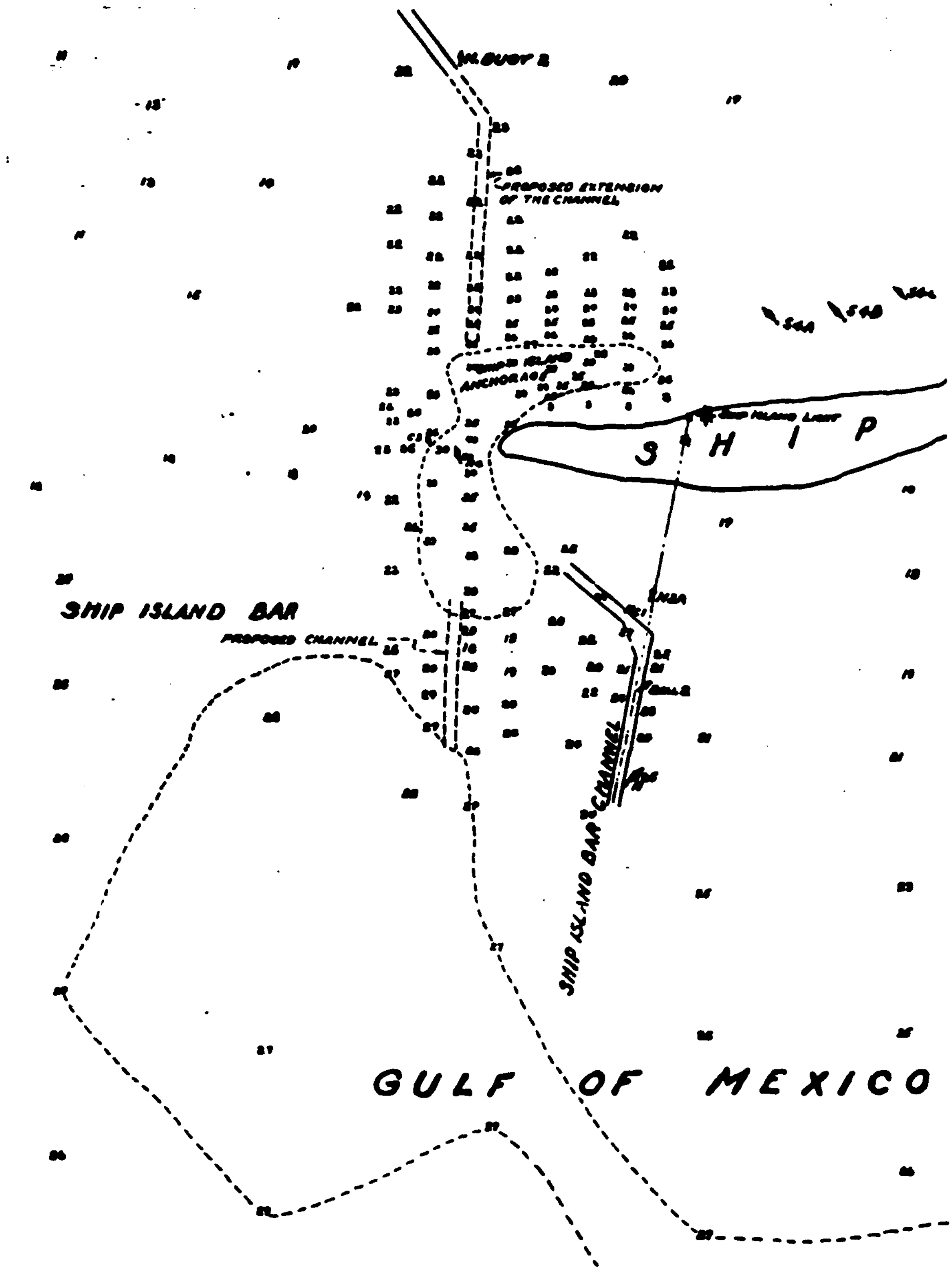

Figure 4. Relocation of Ship Island Bar Channel, 1927 (USCOE, Mobile).

The harbor built by the Gulf & Ship Island Railroad in the late 1800s, and dredged with government aid in 1899, consisted of long piers projecting from shore into the Mississippi Sound and protected by a timber and stone breakwater bearing southeast from the end of the west pier. A replacement timber and stone breakwater was constructed in 1924 under state and city sponsorship, with Corps of Engineers support. This stretched from a point 950 ft south of the southern end of the west pier, for a distance of 1,400 ft southeast into the Mississippi Sound. By 1948, the breakwater had fallen into disrepair and the gap between the west pier and the breakwater filled by two beached steel barges (H. Doc. 112, 81st Congress, 1st Session). Local interests developed a 26 acre small boat harbor to the east of the anchorage basin in 1950 (Figure 5). This was served by a 100 ft wide, 8 ft deep, and 4,300 ft long approach channel. The River & Harbor Act of July 3, 1958 authorized government maintenance of the small boat harbor and channel, on the condition that local interests provided spoil areas and easements (S. Doc. 123, 84th Congress, 2nd Session).

Over the course of nearly a century of channel maintenance, the spoil areas for disposal of dredged material have been in generally the same locations. An undated map by Major Rossell (presumed to be from the late 1890s) entitled "Sketch Showing Proposed Location of Dredged Channel and Anchorage Basin at Gulfport, Mississippi," designates "dumps" to the north, south, and west of the proposed anchorage basin and to the east of the Gulf & Ship Island Railroad pier flanking the basin on the east. Later, a USCOE project map shows spoil areas 1,500 ft south of the breakwater and parallel to the Gulfport channel at a distance of 2,000 ft west in 1961. In 1962, the project map locates the spoil areas parallel to the entire length of the Gulfport channel, at a distance of 2,000 ft to both east and west. Disposal areas for the Ship Island Bar channel on the 1985 project map are located parallel to the channel and at a distance of 3,300 ft to the west and 4,050 ft to the east.

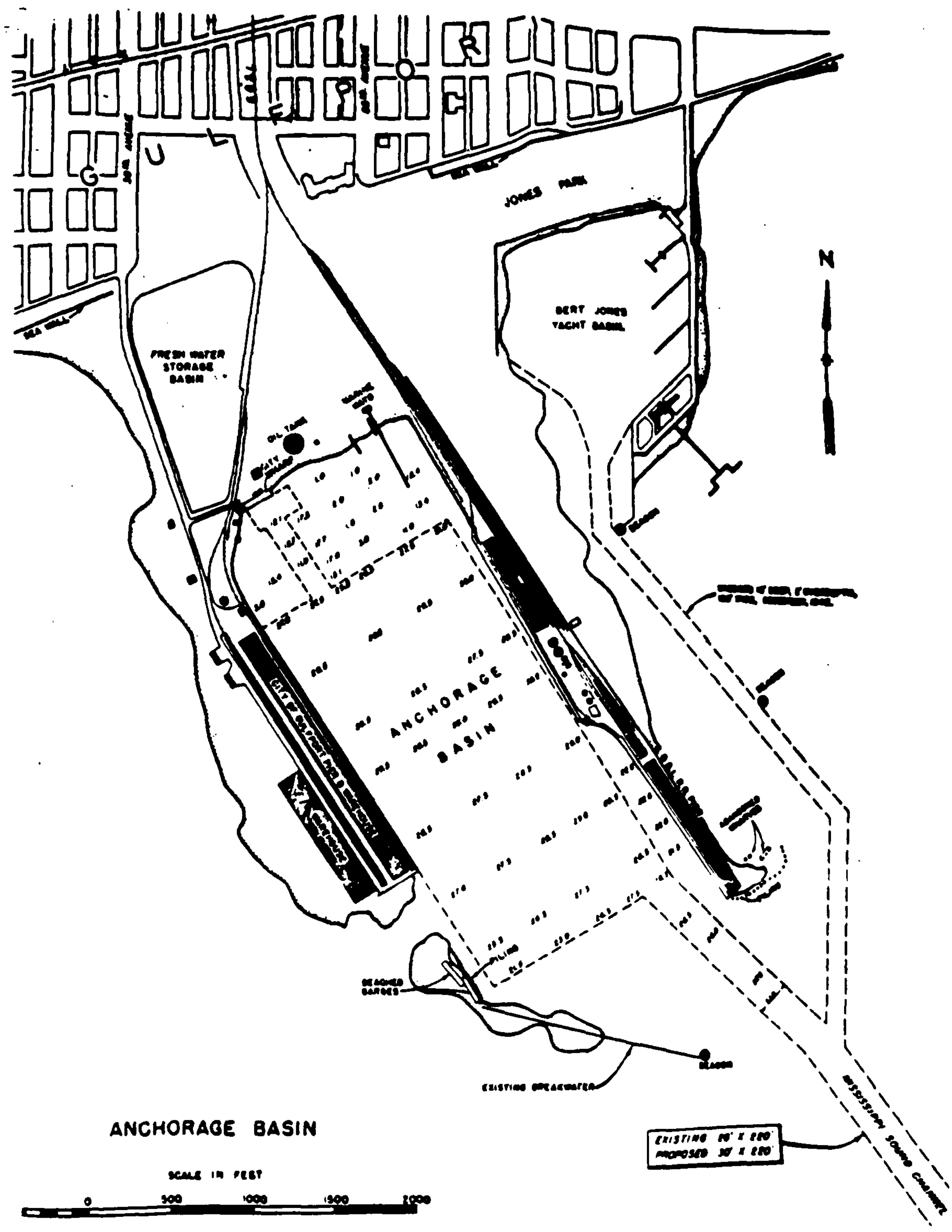

Figure 5. Gulfport Anchorage and Yacht Basins, 1950 (USCOE, Mobile).

IV

SHIPWRECK COMPILATION AND CONCLUSIONS

Proposed modifications to the navigation channel at Gulfport will result in a narrow impact corridor along the line of the current channel. The following compilation of reported shipwrecks encompasses a somewhat larger area in the interest of thoroughness, as wreck locations are rarely specific. The study area investigated covers the sea approaches to the Ship Island channel, including Ship and Cat Islands, the Mississippi Sound between the barrier islands and the coast, and the port facilities at Gulfport (Figure 6). This is an area from roughly 30° north latitude to the coast and from 88°50' to 89°10' west latitude.

The most comprehensive source for shipwrecks in the area is Berman (1972). He lists 34 recorded wrecks for the Mississippi Sound in general. Ten of these, lost in the period 1845 to 1915, are within the study area:

The Edward E. Barrett, a 69 ton schooner built in 1883 and stranded on Ship Island on July 5, 1916.

The Emerald, a 419 ton sidewheel steamer built in 1859 and snagged at Cat Island on January 5, 1868, with three lives lost.

The Flourine, a 38[illegible] ton bark built in 1881 and stranded on Cat Island on September 17, 1906.

The Fred W. Ayer, a 387 ton schooner built in 1903 and stranded on Ship Island on September 22, 1920.

The Galveston, a 545 ton sidewheel steamer built in 1845 and stranded on Ship Island on November 25, 1851.

The Jennie S. Hall, a 450 ton schooner built in 1881, which foundered at Gulfport on August 14, 1916, with all lives (7) lost.

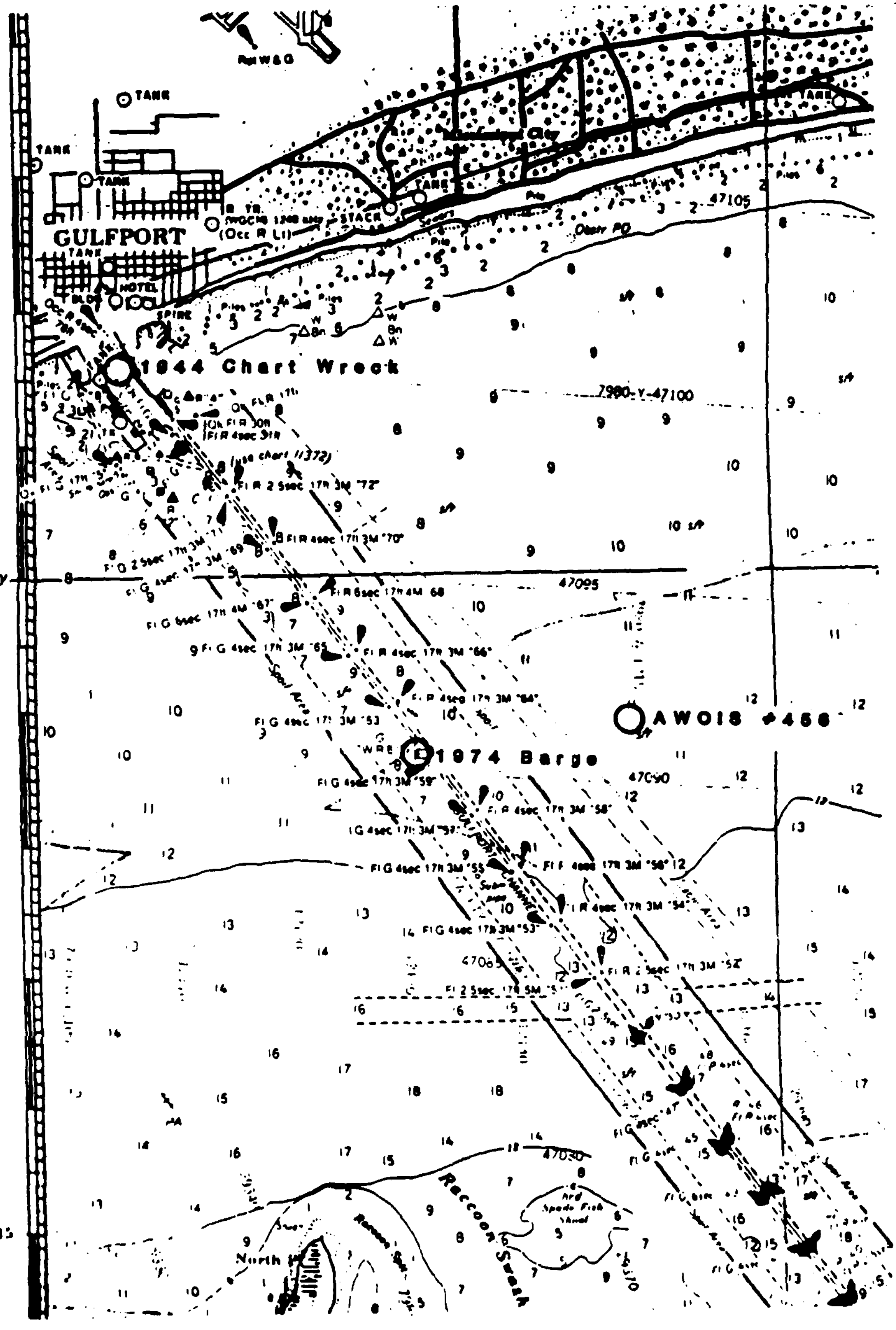

Figure 6. Reported Vessel Losses in Study Area.

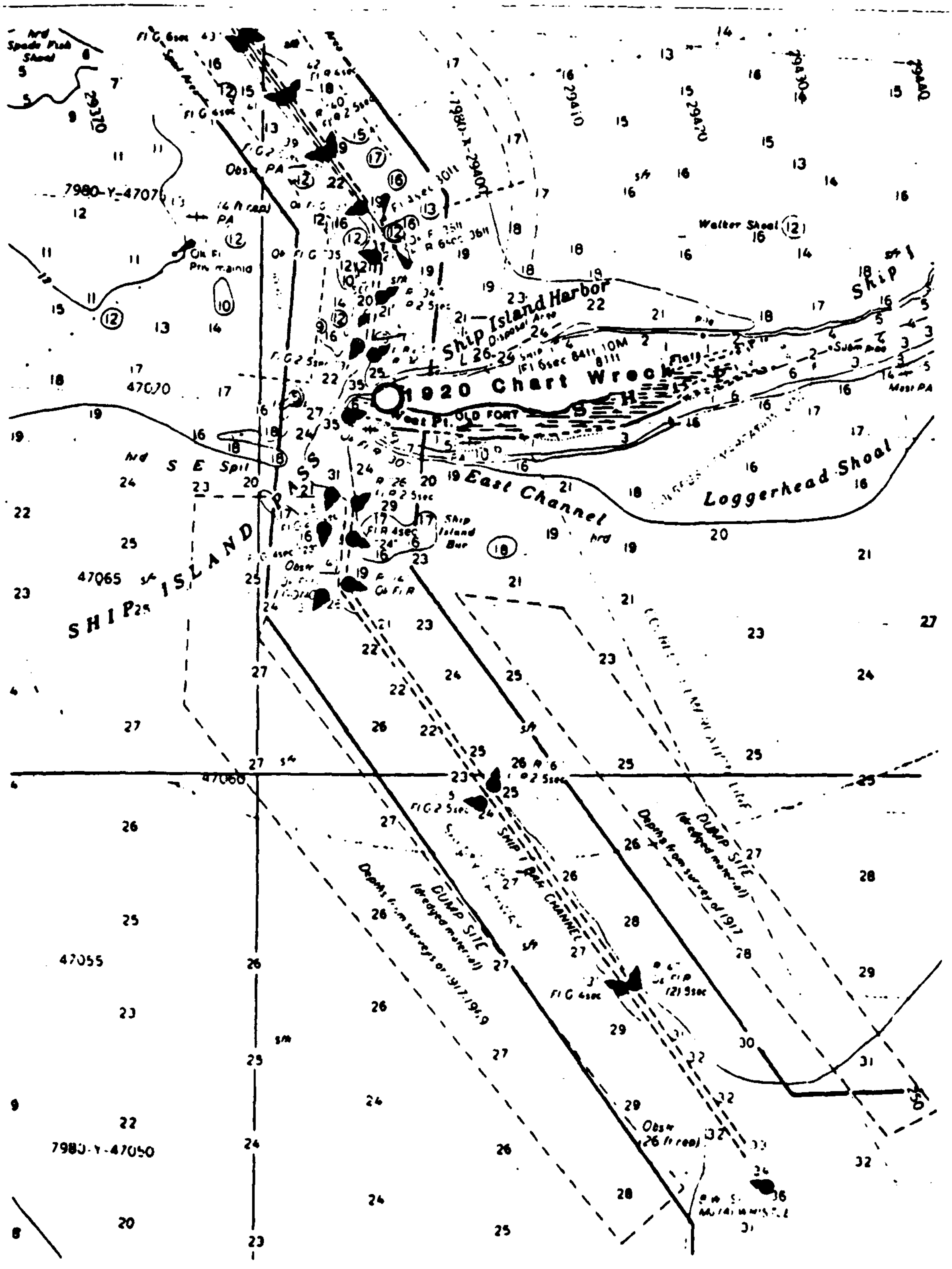

Figure 6. Reported Vessel Losses in Study Area (Continued).

The Ludlow, a 762 ton schooner built in 1900, which burned at Gulfport on May 27, 1925.

The Mary G. Dantzler, a 490 ton schooner built in 1915, which foundered off Ship Island on July 5, 1916, with all lives (8) lost.

The William C. Young a 199 ton sidewheel steamer built in 1854, which foundered at Ship Island on August 15, 1860, with seven lives lost.

The Mist, a steamer (?) built in 1863, which was lost at Ship Island on an unknown date.

A review of available primary sources was performed in an attempt to provide more detail on these vessel losses. Editions of coastal Mississippi newspapers preserved on microform at the Mississippi Department of Archives and History, Jackson and the Harrison County Public Library, Gulfport, contained details on three of the vessels. The newspaper collection is not complete for this area and no additional information was available for the pre-twentieth century wrecks (the Emerald, Galveston, William G. Young, and Mist). Somewhat surprisingly, no mention of the fates of the Fred W. Ayer (1920), Jennie S. Hall (1916), and Ludlow (1925) was made in coastal newspapers in the days following the mishaps. Details were located on the final three vessels, the Edward E. Barrett (1916), the Flourine (1906), and the Mary G. Dantzler (1916), all victims of hurricanes.

The headline of the Biloxi Daily Herald of September 27, 1906, proclaimed a "Worse storm than that of October, 1893 . . . Broke in its greatest fury early this morning." Hundreds of schooners and small boats which had sought refuge in the Back Bay at Biloxi had been swept into shore by high winds, tangling up against wharves and shipyards. In the next day's edition, little damage was reported in Gulfport . . . "The big pier . . . and the vessels in the harbor suffered comparatively no damage." Four vessels anchored at Ship Island, however, were beached or sunk. The Flourine was reported ashore at Goose Point (formerly on

the island's north shore). The wood-hulled Norwegian ships Hercules and Magdeline were lost, while the iron hulled bark Nunberg was stranded on shore (and later refloated). The main quarantine station on the island had been destroyed by the storm. Three or four schooners were beached at Gulfport, with one capsized and another sunk in the anchorage. Interestingly, the "finest pilot boat on the gulf", the Edward E. Barrett, safely rode out the storm at anchor midway between Ship Island and Biloxi.

The 1916 hurricane proved equally devastating. The Daily Herald (9/7/1916) reported an estimated 30 to 40 boats destroyed in the Biloxi/ Gulfport region. Although no ships in Gulfport Harbor were seriously damaged, the barge Champion was "beat to pieces on the west side of the basin," and two schooners were beached on the port's west side.

At Ship Island, the large Norwegian vessel Ancenis, with a million feet of lumber on board, was holed and reported slowly sinking. Fear was expressed for the Mary G. Dantzler, carrying a load of phosphate and commanded by Capt. L.S. Foster, recently married and on a bridal trip with his wife. The Edward E. Barrett, survivor of the 1906 storm, was reported beached near the center of the west end of Ship Island. Joining it was the 1,500 ton barge Bernice and, farther to the east, the four masted ship John Meyer.

On the following day (September 8), the Ancenis was reported beached on the island. It would later be floated and towed to Mobile for repairs (Biloxi Daily Herald, 7/13/1916). The schooners Mary G. Dantzler and M.A. Achorn, however, were washed out to sea and sank, "all trace of them and their crews being lost." Debris from the Dantzler was found on the 10th of September off Deer Island and the west beach in Biloxi. Captain Foster and his wife, along with seven crewmen, were never found. Joining the casualty list that day was the mailboat Hermes, reported wrecked on the south side of Ship Island.

It is reasonable to assume that most of the vessels beached at Ship Island and Gulfport Harbor were salvaged, either refloated, as in the

case of the Ancenis, or broken up and usable vessel components and cargoes recovered. One example of later salvage is reported in the U.S. Army Corps of Engineers Annual Wreck Removal Report for 1919. An unnamed vessel sunk on the east side of Gulfport Harbor was "blasted with dynamite and the wreckage removed" (USCOE 1919:1991). This is the only wreck removal reported in the study area in the annual listings for the years 1899 to 1924. Those lost offshore, however, such as the Dantzler, Achorn, and Champion, were broken up by storm action and claimed by the sea.

The 1982 edition of the navigation chart for the study area (#11373) contains thirteen wreck symbols within three nautical miles east and west of the Gulfport channel (Figure 6). Five of these are located within the safety fairway. A search of available charts, dating back to 1908, was conducted to determine the antiquity of these wrecks. The symbols on the current chart apparently represent recent shipwrecks, as they do not appear on charts as late as 1944, but are marked on the 1974 chart Symbols on charts predating 1944 are later removed. This is the case for a wreck located north of Ship Island's West Point in 1920 (Chart 1267) which is removed by 1933 (Chart 1267) (Figure 6). The 1944 edition of chart 1267 locates a wreck at the extreme north end of the Gulfport anchorage basin (Figure 6). This symbol does not appear on the 1974 or 1983 editions of Chart 11373. It can be assumed that these vessels no longer posed a hazard to navigation and thus were not plotted on the charts, or they were salvaged. Both situations occur regularly in the case of small, local vessels. John Foretich, captain of a Gulfport pilot boat, reports that most of the chart symbols in the channel areas represent fishing vessels or private yachts which have been removed or have broken up on the seafloor (Interview of February 17, 1987).

Captain Foretich also reported that the symbol near beacon 61 A three miles from Gulfport represents a 110 ft barge loaded with slabs of concrete destined for erosion control at Fort Massachusetts in 1974 (Figure 6). In addition, the barges placed in the gap between the breakwater and anchorage basin at Gulfport in 1948 (see Figure 5, Section III) have completely disintegrated.

Several other sources provide nonspecific data on potential shipwrecks in the study area. The National Oceanic & Atmospheric Administrations's AWOIS printout lists an unknown bottom obstruction (#456) one mile east of the safety fairway (Figure 6). Marx (1975:186) reports that two unidentified Spanish caravels, sent on a exploration voyage from Veracruz, wrecked on the south side of Ship Island in 1643. Marx's contention that the island derived its name from this incident is not supported by the later French accounts. Finally, a copy of an early newspaper account in the possession of local historian M. James Stevens details the fate of the steamer Red Chief. On June 4, 1866, the Red Chief, enroute to New Orleans with a cargo of lumber, was caught in a severe gale while entering Ship Island Pass. "She sprang a leak and sunk in eighteen feet of water, and is a total wreck. No lives were lost" (New Orleans Times, June 6, 1866).

It is apparent that the level of maritime activity in the Ship Island and, more recently, Gulfport locales has been matched by the frequency of maritime disasters. In addition, for every vessel loss noted in some form or fashion, there probably exists another whose record is now obscure. The preceding compilation does not include any historically significant shipwreck with an exact location known to be within the Gulfport channel. The potential for the existence of such a wreck, however, cannot be discounted. This is particularly true of the Ship Island Pass and historic anchorage off the western end of the island. With such a potential in mind, it is recommended that a remote sensing survey of that portion of the channel between beacons 37 and 13 be conducted. Identification of potential shipwreck sites can be accomplished using a proton magnetometer and a side scan sonar as minimal instrumentation. Range-range positioning and 50 m survey lane spacing will insure accurate and comprehensive coverage of the area. These procedures are recommended prior to proposed channel modifications.

V

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Mississippi Department of Archives and History

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Telephone 601-354-7326

Established 1902

February 1, 1989

Corps of Engineers, Mobile District
P. O. Box 2288
Mobile, AL 36628-0001

Attention Mr. Hugh A. McClellan, Chief, Environment
and Resources Branch

Dear Mr. McClellan:

RE: Draft report: "Underwater Archaeological Investigations Ship Island Pass, Gulfport Harbor, Mississippi" (89-020)

We have reviewed the archaeological survey report of Jack B. Irion (GAI Consultants) on the above mentioned project. No cultural sites eligible for listing in the National Register of Historic Places will be affected. We, therefore, have no further reservations regarding this undertaking.

There remains a very remote possibility that unrecorded cultural resources may be encountered during construction. Should this occur, we would appreciate your contacting us immediately so that we may take appropriate steps under 36CFR800, part 11, regarding our response within forty-eight hours. If further clarification is needed, please contact this office at 354-7326.

Sincerely,

Elbert R. Hilliard
State Historic Preservation Officer

Roger G. Walker

By: Roger G. Walker
Interagency Coordinator

RGW/gp

cc: Clearinghouse for Federal Programs

Dottie
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United States Department of the Interior

NATIONAL PARK SERVICE
SOUTHEAST REGIONAL OFFICE
75 Spring Street, S.W.
Atlanta, Georgia 30303

IN REPLY REFER TO:

February 8, 1989

Mr. Hugh McClellan
Chief, Environment and
Resources Branch
U.S. Army Corps of Engineers,
Mobile District
Post Office Box 2288
Mobile, Alabama 36628-0001

RE: Review of draft report entitled "**Underwater Archeological Investigations, Ship Island Pass, Gulfport Harbor, Mississippi**" prepared by GAI Consultants, Inc.

Dear Mr. McClellan:

We have reviewed the referenced report and agree with the conclusions and recommendations of the author. The report adequately fulfills the requirements of the work specifications and we have no additional comment.

We would appreciate receiving a copy of the final version if sufficient numbers are available.

Sincerely,

John E. Ehrenhard

John E. Ehrenhard
Chief, Interagency Archeological
Services Division

Report No. COESAM/PDER-89/002

U.S. ARMY ENGINEER DISTRICT, MOBILE
P.O. BOX 2288
MOBILE, ALABAMA 36628-0001

UNDERWATER ARCHAEOLOGICAL INVESTIGATIONS
SHIP ISLAND PASS, GULFPORT HARBOR, MISSISSIPPI

CONTRACT NUMBER DACW01-89-C-0006

Jack B. Irion
JACK B. IRION
PRINCIPAL INVESTIGATOR

GAI CONSULTANTS, INC.
570 BEATTY ROAD
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PROJECT 88-354-10

JANUARY 1989

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ABSTRACT

An archaeological Phase II assessment of five magnetic anomalies has been completed as part of a planned deepening and widening of the Gulfport Harbor channel by the U.S. Army Corps of Engineers, Mobile District. A documentary research program was also implemented in various federal archives in order to expand the list of potential shipwreck sites in the Gulfport area. This document presents the results of the remote sensing and diving investigation of the five anomalies and a compilation of information on eight additional shipwreck sites in the Gulfport area. Neither the documentary research nor the physical examination of magnetic targets yielded evidence of significant historic or prehistoric cultural resources in the project area. No further work is recommended.

PROJECT BACKGROUND

The Mobile District, United States Army Corps of Engineers is considering improvements to the existing Federally authorized Gulfport Harbor, Mississippi navigation channel. The improvements include deepening and widening the existing channel for a distance of approximately 20 miles and realignment of the existing channel through Ship Island Pass.

Documentary research was conducted in 1987 as part of the studies undertaken to insure that significant historic properties will not be affected by this action. This study, entitled "Documentary Research, Submerged Cultural Resources in the Vicinity of Gulfport, Mississippi" failed to locate any historically significant shipwrecks with an exact location within Gulfport Channel (Mistovich 1987:27). The report recommended, however, that a remote sensing survey be conducted between beacons 37 and 13, which is the area of the proposed new channel dredging for the preferred realignment around the west end of Ship Island.

In October 1986, September 1987, February/March 1988, and April 1988 a number of potential channel realignments were surveyed for cultural resources by personnel from the Mobile District, U.S. Army Corps of Engineers (Mobile District 1988a). The remote sensing equipment array consisted of a magnetometer, a side scan sonar and a depth sounder. Real time positioning was maintained using radio-positioning equipment. As a result of this survey, five anomalies were recommended for Phase II evaluation in the selected alignment.

GAI Consultants, Inc. (GAI) was contracted to provide an underwater archaeological evaluation of the five anomalies for potential eligibility to the National Register of Historic Places. Fieldwork took place between November 7 and November 21, 1988. The field crew consisted of the Principal Investigator and five underwater archaeologists, all of whom are certified divers. The fieldwork utilized both SCUBA and surface-supplied underwater breathing equipment. The diving platform consisted of a 42-foot aluminum-hulled crewboat driven by twin Detroit diesel engines.

The most limiting factor to the field work proved to be seasonal south winds which blew in excess of 20 knots on certain days during the project. The southerly winds built up six to eight foot rollers in the exposed project area, rendering diving impossible during this time.

The underwater archaeological investigation of Ship Island Pass represents a comprehensive testing program in accordance with the Mobile District's responsibilities for cultural resources under the National Historic Preservation Act of 1966 (PL 89-655) as amended, the National Environmental Policy Act of 1966 (PL 91-190), Executive Order 11593, and the Archaeological and Historical Preservation Act of 1974 (PL 93-2911).

GEOGRAPHICAL AND ENVIRONMENTAL SETTING

The project area lies in Ship Island Pass, west of the west point of Ship Island, 12.5 miles southeast of Gulfport, Mississippi in the Gulf of Mexico. Anomalies BB-1-1 and C-1-6 are located approximately 3,000 feet (0.9 Km) west of the west point of Ship Island. Anomalies A-3-7, A-2-8 and A-1-1 are clustered in an area between 6,000 and 6,500 feet south of the west point of Ship Island (Figure 1).

Gulfport and the Mississippi Sound are located in the Gulf Coastal Plain Physiographic Province and are underlain by consolidated and unconsolidated sediments that range in age from Miocene to Holocene. The Pliocene age Citronelle Formation overlies the Miocene deposits. The Citronelle Formation consists of red to reddish orange and yellow gravelly sand and ranges up to 200 feet thick in the vicinity of Ship Island. Semi-consolidated to unconsolidated sediments of Pleistocene and Holocene age overlay the Citronelle Formation in the Mississippi Sound. A Pleistocene age soft gray plastic clay several tens of feet thick forms the upper layer sediments in the Gulfport Channel beyond Ship Island in the Gulf of Mexico. One to one and one-half feet of gray brown sand overlays the Pleistocene clay layer in the project area (Mobile District 1988b).

Nearby Ship Island is one of several off-shore bars formed by shore-wise currents in the Gulf (Figure 2). Dunes on Ship Island can peak as high as 20 feet above sea level. The dunes vary from small haystack dunes to wandering barren dunes. They are composed of glistening fine to medium white sand with a

negligible quantity of organic matter. Throughout the dune area many blowouts occur, and the island's topography is constantly changing (Brown et al. 1944). The steady westward migration of Ship Island has necessitated the proposed dredging project (Figure 3).

HISTORICAL BACKGROUND

Although the town of Gulfport, Mississippi cannot claim the antiquity or historical influence of her Gulf Coast neighbors, New Orleans and Mobile, the keels of sailing vessels have plied the waters between Cat Island and Ship Island since Pierre Le Moyne, Sieur d'Iberville's French fleet dropped anchor nearby on February 10, 1699. The relatively deep waters in the lee of what is now known as Ship Island were reported by the French to be a good anchorage. The island was first called Ile de Surgeres, in honor of the Comte de Surgeres, a member of Iberville's expedition. Sometime early in the 1700s the name of the island was changed on French charts to the Ile aux Vaisseaux, or Ship Island (Steckel 1975:6; Mistovich 1987:8).

Ship Island's utility as a safe anchorage was useful for provisioning the French settlement at Biloxi, Iberville's base for his systematic exploration for the mouth of the Mississippi River. It briefly served as the capital of the French colony on the Gulf before it was moved to New Orleans in 1720 (Delaney 1981:30). Ship Island's strategic importance was briefly increased when the French anchorage at Dauphin Island was destroyed by a hurricane in 1717 only to be again eclipsed by the establishment of the port of New Orleans in 1722. Warehouse facilities on the island which had served the thousands of colonists as a provisioning station were in disuse by 1724 (Mistovich 1987:8).

With the Treaty of Paris of 1763, the Gulfport area, along with the rest of Louisiana Territory east of the Mississippi

River, was ceded to Great Britain. During both the Revolutionary War and the War of 1812, Britain stationed ships at the Ship Island anchorage. With the arrival of 30 warships and 30 support vessels at Ship Island on December 10, 1814, the British made use of the strategic position of the island to launch raids against New Orleans.

The strategic importance of Ship Island was not lost on Americans after the conclusion of the war, and it was selected in 1856 as one of the locations for a chain of masonry forts established along the Gulf for coastal defense (Figure 4). The Confederates occupied the unfinished fort at the outbreak of the Civil War, naming it Fort Twiggs after the commanding general at New Orleans. Within three months of Lincoln's proclamation of a blockade of the Confederate coastline, a Federal warship, the _Massachusetts_ besieged the fort but failed to dislodge its garrison. Increased Federal pressure divested the Confederacy of this strategic base in September of 1861 and helped prepare the way for the Union assault on New Orleans. Marines from the _Massachusetts_ eventually captured the fort and renamed it in honor of their ship.

Fort Massachusetts was finally completed in 1871, but technological changes in the warfare rendered it obsolete even before it was finished. While masonry forts were fine for the style of warfare of the 1850s, the Civil War had brought about the development of the ironclad warship, the exploding cannon shell, and rifled cannon, all of which were capable of reducing a brick fort to rubble. Fort Massachusetts, with its guns mounted

en barbette, was a virtual dinosaur even before it was completed, and the government essentially abandoned it by 1880.

Around the turn of the twentieth century, Ship Island enjoyed a brief florescence as the main loading point for lumber which was lightered from the mainland in great quantities. Improvements to the port of Gulfport after 1899 allowed ships to sail directly to the port, eliminating the expensive lightering operation. This eliminated Ship Island once and for all as an important commercial anchorage.

Despite the long history of shipping in the vicinity of Ship Island Pass, there are very few recorded shipwrecks and none recorded before the nineteenth century. The majority of these wrecked on the beach at Ship Island. Other hazards to navigation recorded on Coast Chart No. 90 (Mississippi Sound) dating to 1860 include:

Loggerhead Shoal - one mile south from the neck of Ship Island with 16 1/2 feet of water.

The Middle Ground - 1 mile south of the west end of Ship Island with 17 feet of water.

The Knoll - 1 1/4 mile south of the west end of Ship Island with 17 feet of water.

None of these hazards fall within the project area.

Mistovich (1987) reported 10 wrecks recorded in a single secondary source, Berman's (1972) Encyclopedia of American Shipwrecks. Reports of an additional seven wrecks were recorded in Collectors of Customs' Reports of Casualty for the ports of New Orleans and Biloxi in the Judicial, Fiscal and Social Branch of the National Archives. These include the following vessels:

The Raffaele Ramano, a wooden schooner sunk in Mississippi Sound on October 2, 1893.

The Dirigo, a 367 ton brig from Galveston bound for Pensacola, foundered on Ship Island Shoal during a gale on October 11, 1881.

The American schooner F. W. Elmer, sank in Mississippi Sound during a hurricane, October 2, 1893, "vessel smashed, crew drowned".

The Bloom, 34 ton schooner, stranded about a mile west of Gulfport. The vessel was 43 years old when she sank while bound for New Orleans with a cargo of charcoal.

The schooner Dixie, 17 tons, sank on the Dog Keys on March 31, 1877 while en route from Pascagoula to New Orleans with a load of charcoal.

The iron-hulled steamship Josephine, built 1867, sank February 8,1881. Foundered 5 miles SE of the east end of Ship Island while carrying a load of tobacco and cigars from Cedar Key, Florida to New Orleans. The position of the Josephine is recorded on a map drawn by the Corps of Engineers to accompany a report dated September 15, 1881 (Figure 5).

The Schooner Hellen Ellis, built 1867, wrecked on the Dog Keys, February 25, 1882.

An additional wreck was recorded on charts in the collection of the Cartographic Branch of the National Archives:

The schooner George Henry, wrecked on the south beach of the west end of Ship Island. This wreck is recorded on a U.S. Army Corps of Engineers map of Fort Massachusetts drawn in 1868 (RG84-42) (Figure 6).

Despite an exhaustive search of the information on file in the National Archives and Library of Congress relating to historic shipwrecks, no additional shipwreck locations were documented. Neither the wrecks reported by Berman (1972) as cited by Mistovich (1987) nor the wrecks cited above were located anywhere within the potential impact area of the channel construction; most are located well to the east of the channel. No additional historical information has been recovered which would indicate that any historic sites will be affected by the Mobile District's proposed dredging activities.

METHODOLOGY

Relocation of Anomaly Targets

GAI was provided with the coordinates of five target locations by the Mobile District which were to serve as the focus of the investigation (Table 1). These coordinates represented points along pre-established survey tracks at which anomalous signals were detected during the Corps' investigation of the area in September 1987 and February/March 1988 (Mobile District 1988a). The coordinates were not intended to represent the actual location of the source of the anomaly but rather the approximate location within the survey track where the source was detected. A particularly massive object could be detected on two or more of the survey tracks. The Corps' survey tracks were 150 feet (45 meters) apart, running parallel to the proposed channel alignment.

GAI's first task involved relocating and buoying the selected coordinates. A Motorola Miniranger radio-positioning system was employed for the task. This system consists of one range console, a receiver and three transponders with 19 dB antennae. The Miniranger operates at a 9 Gigahertz frequency and is quoted as having an absolute measurement accuracy of ± one meter on each measured range. The range console was interfaced with a Hewlett-Packard 9816 computer system comprising a CPU with integral CRT display, 9121 dual disk drive, Thinkjet printer and 7575 plotter. The computer system runs proprietary survey software which takes over control of the Miniranger, firing it directly and taking three ranges simultaneously to derive a least

squares position fit in real time. Three ranges are received and a position computed every three to five seconds. The position is then printed out onto paper, logged onto disk and displayed on the CRT. The visual display assists the boat operator in guiding the survey vessel to the position. When the vessel was determined to be over the recorded coordinate, a buoy was dropped to mark the location. Visual relationships with landmarks were noted and a fix was taken with a Loran C navigational computer so that the approximate location of the buoys could be recovered in the event of their accidental loss. Buoy loss turned out to be something of a problem because of the heavy traffic of shrimp boats dragging nets in the area.

Immediately following the buoy drop, a magnetic prospection of the vicinity surrounding each buoyed location was made within a radius of 200 feet from the buoy. Track lines approximately 30 feet (9 meters) apart were run both north to south and east to west in order to ensure complete coverage of the area. The purpose of this prospection was to verify the presence of anomalous magnetic perturbations in the general area of the recorded position and to provide a distance and directional fix in relation to the coordinate buoy for later relocation. This task required one day to install and calibrate the equipment and one day to position and survey the coordinates.

Search and Excavation

A number of techniques were utilized for locating and exposing the ferrous source of the anomaly targets. The first step in attempting to define the target was to conduct a thorough

bottom search of the area. The focal point of the search was a location buoy dropped at the anomaly during a boat survey while towing the magnetometer fish 20 feet (6 meters) off the stern. The most effective search method involved a circle search around the location buoy. Attaching one end of a tape measure to the locational buoy anchor, two divers on SCUBA would then space themselves at 5-foot intervals along the tape and swim in a circle around the area. The circle search was gradually widened at 5-foot (1.5 meter) intervals to encompass an area with a radius of 60 feet (18 meters). While conducting the bottom search, in this area, the divers also used steel probes to locate buried objects. The probes could not penetrate the Pleistocene clay layer lying one to two feet (0.3 to 0.6 meter) beneath the sand. The clay represents a culturally sterile stratum. Any artifacts deposited during the historic period would not penetrate below the clay/sand interface.

The swift currents, sometimes up to three knots, which flow through the Ship Island Pass make the use of SCUBA difficult in this area. As a result, communications-equipped surface-supplied air equipment was sometimes employed. The search was conducted by directing the divers through the area with voice communication from the surface. The decreased mobility and the length of the umbilical limited the usefulness of this equipment for search operations. SCUBA was much preferred for this task, although additional safety precautions are necessary when working in current.

When no evidence of the target was found either by visual search or probing, the next step involved the refinement of the location of the target area by remote sensing techniques. This was accomplished by utilizing the magnetometer as a gradiometer to determine the point of maximum magnetic deviation. Once the general location of the anomaly was located and buoyed, the diving vessel was anchored with its stern in the vicinity of the marker buoy. A swimmer would then move the magnetometer fish, which was suspended from a float just above the bottom, over the area at the direction of the magnetometer operator until the maximum reading of magnetic deviation was achieved. This position was further refined by a surface-supplied diver who, at the direction of the magnetometer operator on the surface, would pull the mag fish along the bottom until the greatest deviation occurred. The anomaly buoy was then moved to this location, which became the new focal point of search activity.

Following the repositioning of the marker buoy, intensive probing and excavation took place around the marked location. When probing the Pleistocene clay layer failed to uncover any anomalous features, a trench six feet (1.8 meters) in diameter was excavated to a depth of approximately three feet (1 meter). The bottom of the trench was excavated two feet (0.6 meter) into the Pleistocene clay layer after removal of the sand overburden. Excavation was accomplished by means of a diver-operated hydraulic venturi dredge powered by a two-inch centrifugal water pump.

RESULTS

Five magnetic targets were identified by the Corps of Engineers for diver investigation. Of the five, only two magnetic anomalies were found to still exist near the originally recorded positions.

A resurvey of targets BB-1-1 and C-1-6 showed the area to be magnetically clean. Both of these anomalies, as identified during the original Corps survey, were of relatively low amplitude, with BB-1-1 recorded as 9 gammas and C-1-6 as 110 gammas. Neither target produced a sidescan signature.

GAI's resurvey of the area employed a Geometrics 866 proton magnetometer. The magnetometer fish was towed at a distance of 50 feet astern of the 42-foot aluminum hull crewboat that served as the project's work boat. Transects were run at 50-foot (15 meter) intervals to cover an area of 90,000 square feet (8,360 m^2) with the positioning buoy which had been deployed with the aid of the Miniranger at the center of the block. No magnetic anomalies were detected during this operation and it is presumed that whatever had produced the original signature has since been removed from the site, probably by one of the shrimp boats that drag their nets in these waters.

Two point source anomalies were detected in the vicinity of targets A-1-4, A-2-8, and A-3-7. An extremely strong anomaly producing a bipolar signature of 3100 gammas was detected midway between coordinates for A-1-4 and A-2-8. The configuration of the anomalous signature suggests a single object of high mass.

The second anomaly was recorded closer to the channel at the midpoint on a line between the coordinates for A-2-8 and A-3-7. The GAI resurvey recorded a monopolar signature of short duration with a deviation of 430 gammas. Although the two anomalies were quite close to one another (within 120 feet) they were clearly generated by unrelated, isolated point sources.

The precise location of both anomalies was determined by methods described above. Employing a surface-supplied diver to pull the magnetometer fish along the bottom produced such a strong reading at one point on the anomaly between A-1-4 and A-2-8 that the magnetometer went completely out of phase, deviating as much as 20,000 gammas between readings. The machine reacted in this manner, only when the sensor, located in one very isolated location, indicated that the fish was precisely over the target.

Despite extensive probing and excavation, (often to a depth of three feet in the areas which the magnetometer indicated to be the precise location of the targets) no evidence of the source of the anomaly was found in either instance. One is forced to conclude that the objects lie buried below the Pleistocene clay layer at a depth greater than three feet below the sea floor. It is apparent from the magnetic readings that the objects are of large mass, yet small in area. A similar situation was encountered by the Principal Investigator in Mobile Harbor in 1983. In that instance, it was determined after six days of excavation that the target source was a core drill casing (Irion and Bond 1984:48). Considering the amount of bottom sampling which has

been performed over the past several decades, both by the Corps of Engineers and the oil and gas industry, it is highly likely that this would account for one or both of the anomalies in the study area.

RECOMMENDATIONS

Although the depth of the two buried objects that produced the anomalous signatures precluded their firm identification, it may be definitely stated that they are not potentially eligible to the National Register of Historic Places (NRHP).

The historical precis assembled by Mistovich (1987) clearly indicates that there are no known structures such as lighthouses or fortifications in propinquity to the project area aside from those currently standing on Ship Island. Therefore, the only conceivable site which could exist in this location which could be potentially eligible to the NRHP is a shipwreck. It is virtually impossible, however, that shipwreck remains would lie below the level of the Pleistocene clay. In a similar situation in a Texas offshore environment, it was found that artifacts of shipwrecks from various periods had migrated through the sand down to the surface of the Pleistocene clay but they did not penetrate the clay to any appreciable depth (Arnold 1982:46). The extensive probing and excavation which was undertaken directly over the anomaly location could not have failed to locate vessel remains under the one- to two-foot thick sand horizon. It must be assumed, then, that the object must have been forcibly intruded into the clay. The most logical explanation for the forcible intrusion of a ferrous object into the clay substrata of the ocean floor is one of mechanical geological prospection.

As previously stated, the two anomaly targets which still exist in the study area have been demonstrated to be single, isolated occurrence unassociated with any site which meets the

criteria for inclusion in the National Register of Historic Places. As a result of these investigations, no further work is recommended. It is further recommended that cultural resources clearance to be granted for the proposed channel modification.

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Table 1

INVESTIGATED ANOMALIES

Anomaly Number	Gammas (as recorded by COE)
A-1-4	60 - 240 series
A-2-8	700
A-3-7	45
BB-1-1	9
C-1-6	110

APPENDIX A

DIVING SAFETY PLAN

U.S. ARMY ENGINEER DISTRICT-MOBILE
P.O. BOX 228/CT-PC
MOBILE, ALABAMA

DIVING SAFETY PLAN
FOR
UNDERWATER ARCHAEOLOGICAL INVESTIGATIONS, SHIP ISLAND PASS, GULFPORT HARBOR, MISSISSIPPI

GAI CONSULTANTS, INC.
570 BEATTY ROAD
MONROEVILLE, PENNSYLVANIA 15146

PROJECT 88-354

OCTOBER 1988

D-5-81

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OPERATING PROCEDURES

General Safety Procedures

The Dive Officer will also be in charge of general project safety.

- All facilities, equipment, vessels and safety equipment will be inspected by the Dive Officer weekly.
- Training sessions, seminars or procedural review may be requested of the Dive Officer at any time. There will be periodic review of objectives and goals of Project to update all participants. Regular meetings regarding safety and operations will be held weekly.
- Training sessions, seminars of procedural review may be requested of the Dive Officer at any time. There will be periodic review of objectives and goals of Project to update all participants. Regular meetings regarding safety and operations will be held weekly.
- All personnel will be responsible for knowing safety regulations herein stated and otherwise specified by the Dive Officer.
- It is the responsibility of each project participant or visitor to conduct all activities in a safe manner.
- All accidents or injuries will be reported to the Dive Officer immediately, regardless of how slight. A report of injury form will be completed.
- All personnel will be familiar with the location of safety equipment, fire extinguisher and procedures.
- Standard operations procedures are established for all machinery. Operators will familiarize themselves with these procedures before operation.
- A maintenance and operation log will be maintained for all operating machinery.
- Evacuation route to emergency medical facilities will be established for all areas of the bay and all persons will know these routes. There will be sufficient

gasoline maintained in all vehicles for emergency use. There will be a vehicle available for emergency use at all times during diving operations.

- o Each member of the project is expected to be proficient at cardio-pulmonary resuscitation and basic first aid procedures as well as Project specific emergency situations as deemed necessary by the Dive Officer. Training will be given prior to and during the project for those not proficient and those requiring review.
- o Project personnel will be issued written material on safety and are responsible for knowing its contents, e.g., Coast Guard boating safety publications, American National Red Cross First Aid Manual, and Cardio-Pulmonary Resuscitation Manual.
- o Non-slip footwear will be worn at all times while on vessels. Life jackets are not required in enclosed areas or by divers in wetsuits. Sufficient life jackets will be on board for each person.
- o A fire extinguisher will be aboard each vessel, in each vehicle and in the immediate vicinity of any motor or fuel storage area. These will be checked weekly.
- o All cans of fuel will meet prescribed OSHA standards and will not be stored aboard any vessel except in transit and then only when necessary.

Diving

All divers will adhere to this standard and all revisions that develop during the Project.

- o All divers will be required to demonstrate proficiency in pre- and post-dive procedures, water skills and theory of diving.
- o Each diving participant must show at least basic certification and should present the Dive Officer with their personal current dive log. Visiting divers from governmental agencies will have appropriate current diver certification. All divers will be cleared through the project officer on project specific procedures.

- All divers will be cleared by the Dive Officer or his designate in his absence.
- There will be no decompression dives done on this project. Divers working hard in cold water will monitor their time and not come within 15 minutes of any no-decompression time limit for the working depth.
- A stand-by diver will be present whenever dive operations are being conducted.
- Planning sessions will precede each dive. This session will include an assessment of safety aspects, potential hazards, task to be undertaken, emergency procedures and any modification to operating procedures necessary for specific operation.
- All dives will be logged and written comments are required of the diver immediately upon completion of the dive.
- A diver will report any injury or abnormal sensation, regardless of how slight, to the Dive Officer.
- Colds, upper sinus infections, respiratory infections, and ear infections are contra-indicated in diving. It is every project participants' responsibility to maintain good health during the project.
- Medication for ears. Divers will use the medicated solution which is supplied in the ears following each dive.
- The Dive Officer will be informed of the ingestion of any medication.
- A diver shall remain awake for at least one hour after a dive.
- There will be no flying done for a minimum of 12 hours following a dive.
- It is the responsibility of the divers to disqualify themselves from a dive or terminate a dive at any time it is felt that the dive should not be made or continued, or even if there is a reasonable doubt. Each

diver is expected to assess their own physical and mental condition before each dive. If you are not totally confident that you can handle the assigned task or any emergency situation that should arise, you are expected to opt out out of a dive. An explanation is not necessary.

- o An "ALPHA" diving flag will be displayed at all times during diving operations.
- o Periodic evacuation and emergency drills will be carried out on each diving vessel to standardize and familiarize all personnel with these procedures.
- o All persons will be proficient in radio operation and follow established communication procedures should emergency evacuation be necessary.
- o Air supplied to the diver shall not contain:
  1. A level of carbon monoxide in excess of 20 ppm.
  2. A level of carbon dioxide in excess of 1000 ppm.
  3. A level of oil mist in excess of 5 milligramsper cubic meter.
  4. Detectable moisture, dirt, particulates or odor.
- o Diving shall not take place within eight hours of the consumption of alcohol, two hours of consumption of a heavy meal or on an empty stomach.
- o A diver who has performed arduous work in a one-hour period preceding a dive shall not be assigned stand-by diver duties for dives over 12 feet.

Equipment Selections and Use

Scuba Diving. All Scuba diving will be done in buddy teams or be line tended. In conditions of current exceeding one knot Scuba divers will be line tended from the surface with a rope (so that it may be cut if necessary) or have a quick release mechanism.

In low visibility water a surface float attached to divers may be required.

Equipment

- All equipment will be inspected by the Dive Officer weekly.
- All personal gear will be marked.
- Prior to each dive, surface tender (if using line to surface) or buddy will check diver's equipment for proper location and function.
- All demand regulators will be inspected at least every six months and be of proper construction to operate at maximum cylinder pressure.
- All divers will have a submersible pressure gauge, operational and affixed to breathing supply. This gauge will be within ±5 percent accuracy and equipped with a burst disc.
- All hoses will be inspected prior to each dive for signs of cuts or abrasions. This examination will take place while hose is under pressure so that leaks and bulges can be detected.
- All divers will carry sharp knives.
- Divers will carry reserve air supply as a functioning J type reserve valve or extra tank independent of main air supply.
- All tanks will meet Department of Transportation requirements as well as comply with applicable provisions of 29 CFR, Sections 1910166-171.
- Tanks will be inspected at least every 6 months and be under current hydrostatic test date.
- Tanks will be protected from heat, blows, and falling at all times.
- A buoyancy compensator (B.C.) capable of at least 30 pounds lift at the surface will be worn at all times. The B.C. will have provisions to be activated orally and mechanically by compressed gas. All units will have an over pressure exhaust valve.

- o All harnesses and weight belts shall have quick release buckles.
- o All compressed air used to fill tank cylinders will have a current (1 year) analysis and meet specifications as stated. Air compressors will be maintained according to manufacturer's specifications. If air is purchased from a commercial source, these records will be checked prior to filling tanks.
- o The Scuba tank pressure will be recorded on the log sheet prior to each dive.

Surface Supplied.

- o Air will be supplied from 235 cu ft air cylinders
- o All divers will carry an independent reserve bail out air supply.
- o Surface supplied divers shall be in voice communication with surface tender.

MASKS:

1. Will be maintained according to manufacturer's specification and only approved spare parts will be used for replacement. No modifications will take place.

2. Will be equipped with a non-return valve and the valve will be checked by the tender prior to each dive.

3. Will have reliable oral communications between the tender and the diver.

HOSES:

1. Will have bursting pressure at least four times greater than operating pressure of at least 80 psi over bottom (ambient)

2. Will be of sufficient size for flow rates of 4.5 cubic feet per minute.

3. Will be kink resistant, marked in 10-foot lengths from the diver end and be equipped with proper corrosion resistant fittings.

4. Will be coiled or figure-eighted to prevent twists at all times when not in actual use. The hose ends will be capped at all times when not in use. Each hose will be inspected prior to each dive.

5. All compressor volume tank and hose connectors will be secured to prevent accidental disconnection.

6. Divers will wear harnesses with quick release attachment to safety line. Safety line will have a breaking strength in excess of 500 pounds.

o The quick release will be attached to the harness in a manner such that the strain distributes over the diver's body.

o The tender will help the diver off and on all equipment, adjust and secure it. The tender will check and insure that the diver is properly rigged and adjusted immediately before the diver enters the water. The diver will not enter the water until clearance from tender is given. The diver will check all equipment for proper functions, immediately upon submerging. The tender will monitor and periodically report bottom time to the diver.

o Tender should allow two to three feet of slack in the diver's line, but should be able to feel the diver from time to time. Signals cannot be felt in a slack line. The diver's hose will be held in hand with proper tension at all times.

o While it is the tender's duty to have equipment checked out and prepared for each dive, each diver will check all equipment used on the dive to insure proper function and location prior to entering the water.

o All signals, whether hand or line, are active and are to be returned with one exception of a 4-4-4 line signal for emergency haul up. All persons involved with surface supplied equipment either as a tender or diver will demonstrate knowledge of and proficiency in the standard line pull signals to satisfaction of Dive Officer.

ACTIVITY HAZARD ANALYSIS

Numerous potential hazards exist for humans working within the marine environment. Potential hazards are identified below with the appopriate response indicated.

Dangerous Marine Organisms

Potentially dangerous marine organisms which inhabit the Gulf include jellyfish, stingrays and sharks. The first response to these organisms will be avoidance. In the event of an injury, appropriate first aid will be applied and, if severe, the patient evacuated to the nearest medical facility.

Diver Fouling

Diver fouling can occur from the many obstructions, lost fishing nets and lines and cable which are found on the ocean floor, and, in fact, form the object of search in many cases. Procedures to be followed in the event of a fouled diver are as followed:

Scuba Diver. Scuba Diving will always to conducted using the buddy systems. The diver's buddy will assist in freeing his tangled partner.

Surface-Supplied Diver. Notify tender via communications or line signal if necessary. Describe the situation to the tender. The diver should attempt to follow the hose back while coiling the slack. If the diver cannot free himself, he should wait for a second diver. Struggling and panic are the chief potential dangers.

Emergency Procedures in the event of losing communication with a surface-supplied diver:

1. Effect line pull communications immediately. Notify standby diver.
2. Four pulls will be given by the tender to the diver. Diver will answer signal and immediately ascend.
3. If tender receives no answer to four-pull signal, slack should be taken up and signal repeated. Standby diver will be notified.
4. If there is tension on the line but diver provides no response, he is presumed to fouled and possibly unconscious. Standby diver will be dispatched and preparations made for resuscitation and evacuation.

Small Boat Traffic

A potential hazard exists from the small boats which operate in the area. The following precautions will be taken to avoid this potential hazard:

1. The international ALPHA flag indicating a stationery vessel along with the red-with-diagonal white stripe diver-down flag will be prominently flown.
2. A large, international-orange buoy will be set out astern of the dive vessel to warn boats away from the area.
3. If a potential hazard is recognized from an infringing vessel, divers will be notified to return to the dive boat and assistance requested from the U.S. Coast Guard via marine-band radio.

Ship Traffic

A constant watch will be maintained for ship traffic. Divers will be ordered to return to the vessel, and crew will retire to a safe distance until the danger has passed.

Decompression Sickness and Gas Embolisms

No decompression diving shall be carried out under this contract. U.S. Navy Standard No-Decompression Limits will be adhered to with an additional margin for safety accomplished by adding ten feet to the actual depth when figuring no decompression limits and repetitive groups.

ACCIDENT MANAGEMENT PLAN

After the victim of an accident has been removed from the water, a reassessment of the situation will be made immediately. An unconscious diver should be suspected of gas embolism and so treated. Outside help will be summoned immediately.

Summoning Aid in Emergencies

In the event of a serious accident, the U.S. Coast Guard Search and Rescue(SAR) Unit located in will be requested to provide immediate assistance.

- o The Coast Guard will be contacted via marine band radio channels 16 or 22. A crew member will be stationed by the radio throughout the emergency. The telephone number for the U.S.C.G. Station at Gulfport is (601) 863-5818.
- o When contact is made, the caller will declare that the situation is an emergency and state the nature of the emergency.
- o Other information provided to the Coast Guard will include:
    - latitude and longitude of nearest anomaly,
    - prominent land marks,
    - environmental conditions,
    - status of victim,
    - unusual circumstances and number of victims identified.
- o The nearest recompression chamber to the dive site is located at Spring Hills Memorial Hospital, 3719 Dauphin Street, Mobile, Alabama 36608.

APPENDIX B

STATEMENT OF WORK/SPECIFICATIONS

STATEMENT OF WORK/SPECIFICATIONS

UNDERWATER ARCHEOLOGICAL INVESTIGATIONS
SHIP ISLAND PASS

GULFPORT HARBOR, MISSISSIPPI

1. INTRODUCTION:

a. The work and services to be performed consist of intensive submerged historic properties surveys of proposed new channel construction in the Gulf of Mexico and Mississippi Sound in the vicinity of Ship Island, Mississippi. These efforts are associated with proposed improvements to the existing Gulfport Harbor, Mississippi federal navigation channel. Specific areas to be investigated were identified by preliminary underwater remote sensing surveys conducted by the Mobile District, U.S. Army Corps of Engineers in 1987 and 1988.

b. These intensive surveys are in partial fulfillment of the Mobile District's responsibilities for submerged historic properties under the National Historic Preservation Act of 1966 (PL 89-665), as amended; the National Environmental Policy Act of 1969 (PL 91-190); Executive Order 11593; and the Archeological and Historic Preservation Act of 1974 (PL 93-291).

c. Data collected during these intensive surveys will serve as the basis for compiling National Register of Historic Places determinations of eligibility documentation for submerged historic properties located within proposed construction areas. In addition, recommendations for appropriate mitigation efforts for affected National Register eligible properties will be developed.

2. STUDY AREA:
The study area is located to the west of Ship Island in Mississippi Sound and the Gulf of Mexico, as indicated on the attached drawing. A total of five (5) magnetic anomalies that are within the proposed new channel alignment are to be investigated. Table 1 is a list of the anomalies.

3. CHARACTER AND EXTENT OF SERVICES - GENERAL REQUIREMENTS:

a. The Contractor shall furnish the following work and services as detailed in the General Requirements and in the Specific Requirements set forth in Paragraph 6. below. The Contract period is for nine (9) months.

(1) The Contractor shall furnish all labor, plant, survey and diving equipment, boats, transportation, laboratory facilities and associated materials, and services necessary to perform surveys to identify and evaluate the cultural and historic significance of submerged anomalies along the Ship Island Pass segment of the Gulfport Harbor channel.

(2) The survey and diving techniques and remote sensing equipment shall be representative of the state of current knowledge and development. Equipment and methodology to be employed by the Contractor shall be discussed in detail in the Technical Proposal for the Contract.

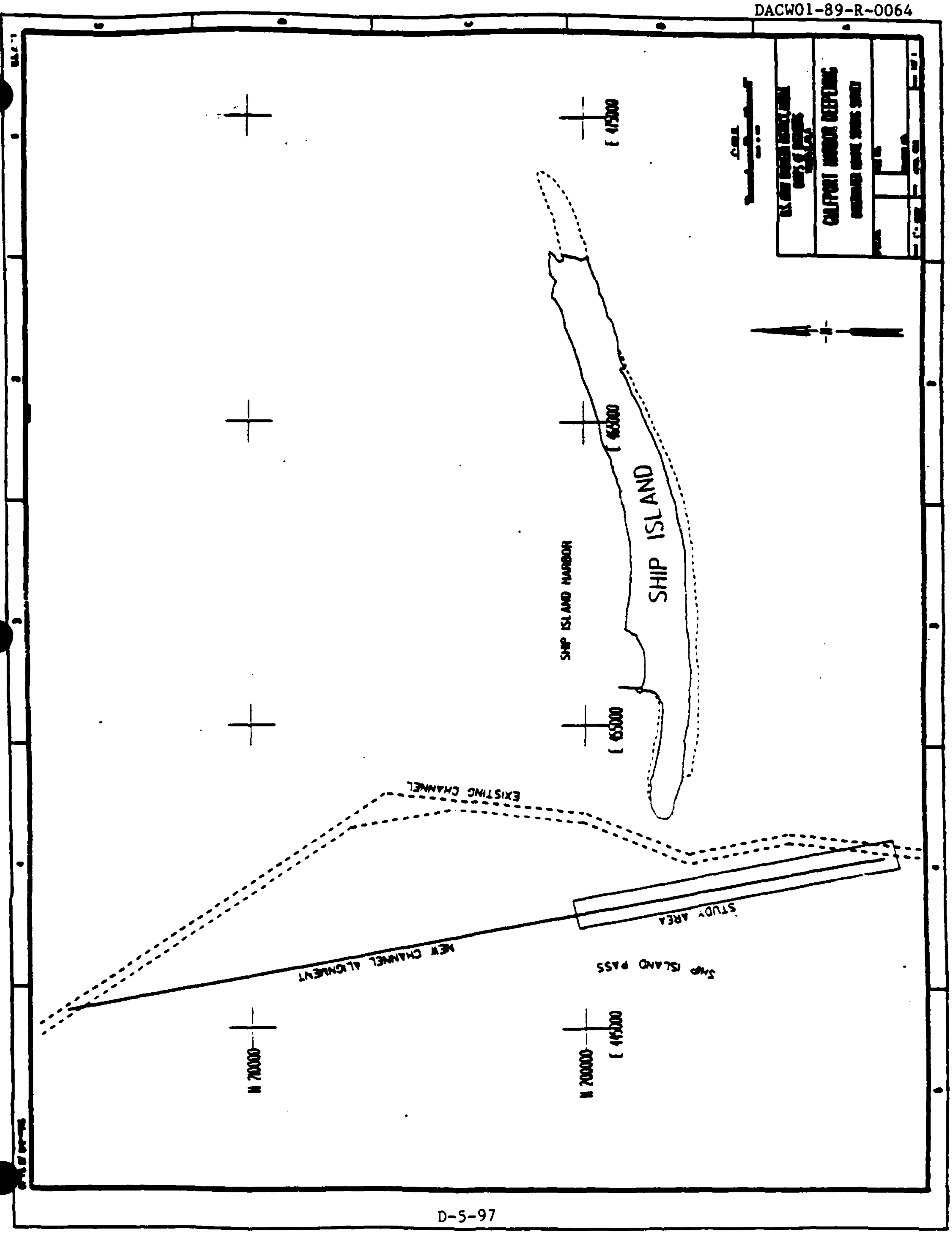

SHIP ISLAND
SHIP ISLAND HARBOR
EXISTING CHANNEL
NEW CHANNEL ALIGNMENT
STUDY AREA
SHIP ISLAND PASS
N 200000

Table 1

Anomaly Number	Gammas
A-1-4	60 - 240 series
A-2-8	700
A-3-7	45
BB-1-1	9
C-1-6	110

(3) Performance of this Contract requires Contractor personnel consisting of the following general catagories: Principal Investigator, Underwater Archeologist, Diving Supervisor, Underwater Remote Sensing Technician, Diver, Archeological Assistant, Draftsman and, and other specialized consultants as necessary. Personnel Qualifications are detailed in Paragraph 7. below.

b. The types of surveys and services to be performed under the terms of this Contract shall include but are not limited to the following:

(1) Underwater Remote Sensing Survey - Reestablishing the locations and delineation of the areal extent of submerged individual anomalies or clusters of anomalies. Northing and Easting (X/Y) coordinates of the anomalies to be investigated will be furnished to the Contractor by the Government.

(2) Diving, Underwater Excavation, Mapping and Underwater Photography- To expose and record the identity, state of preservation, and potential historic significance of submerged anomalies. All diving conducted under this Contract shall be conducted in accordance with U.S. Army Corps of Engineers regulations and the U.S. Navy Diving Manuals, Volumes I and II. Where a difference in standards exist, the more stringent will apply. <u>Diving requiring decompression shall not be conducted under this Contract.</u>

(3) Stabilization and Analysis - Artifacts recovered from the underwater survey and excavations shall be cleaned, stabilized through appropriate chemical and mechanical processes, and analyzed to ascertain the potential historic significance of anomalous areas from which artifactual materials are recovered.

(4) Preparation of Reports - Progress Reports, Management Summary, Draft and Final Reports are required. Format, contents, and schedules for submission of these documents are detailed in the Submission/Reports section of the Statement of Work.

(5) National Register of Historic Places Documentation - Sufficient information shall be obtained during the field investigations and subsequent laboratory analysis to evaluate the potential National Register eligibility of each anomaly investigated. Format and content of this documentation is discussed in the Specific Requirements section of the Statement of Work.

(S) (6) Prior to initiation of field work under this Contract, the Contractor shall submit a Diving Safety Plan to the Contracting Officer for review and approval in accordance with EM 385-1-1, U.S. Army Corps of Engineers, Safety and Health Requirements Manual and, ER 385-1-86, "Safety, Underwater Diving". Written approval of the Diving Safety Plan and Divers qualifications must be received from the Agency Dive Officer prior to start of field work.

4. CONTRACTOR FURNISHED EQUIPMENT:

The Contractor shall furnish all transportation, floating plant, instruments, survey equipment, diving equipment, laboratory and curation facilities necessary to perform the work, including, but not limited to the following:

a. All necessary remote sensing equipment required to reestablish the locations of anomalies to be investigated. The offeror must identify the proposed equipment array to be utilized (including brand name and model) for this work in the Technical Proposal for this Contract.

b. All necessary equipment and personnel to accurately delineate and map anomalous areas and the materials therein. Equipment to be employed and methodologies should be discussed in detail in the Technical Proposal.

c. All necessary equipment to conduct both SCUBA and diving with Surface Air Supply (SAS), including boats and dive platforms that can be operated in Mississippi Sound and the Gulf of Mexico.

d. Equipment to conduct underwater excavations to locate, expose, record, and rebury anomalies. Examples of this equipment include, but are not limited to airlifts, jet probes, and underwater video systems. Detailed discussion of the proposed equipment array must be included in the Technical Proposal for the Contract.

e. Adequate laboratory facilities and equipment to clean, stabilize, and preserve cultural materials that are recovered during diver investigation of the anomalies. Examples of materials that may be recovered are ferrous and non-ferrous metals, wood, fabric, glass and ceramics. Each of these materials require specialized chemical and/or mechanical preservative processes. Proposed facilities and equipment must be identified in the Technical Proposal.

f. Necessary drafting and other office supplies to prepare reports and other data that will be generated under this contract.

g. Access to adequate facilities to permanently curate all records, cultural materials, and other data likely to be obtained under this Contract.

5. DATA FURNISHED BY THE GOVERNMENT AT POST AWARD MEETING (to be Returned at Completion of the Contract):

a. Maps of the Gulfport Harbor channel and proposed improvements with locations of anomalies to be evaluated indicated.

b. Northing/Easting (X/Y) coordinates of anomalies to be evaluated.

c."Documentary Research, Submerged Cultural Resources, Gulfport Harbor, Mississippi"

d. "Underwater Remote Sensing Survey, Ship Island Vicinity, Gulfport Harbor, Mississippi".

e. ER 1105-2-50.

f. EM 385-1-1

g. SAD Forms 2068-R, 2069-R, and 2070-R.

6. SPECIFIC REQUIREMENTS:

a. Under this Contract, submerged historic properties investigations shall be conducted for five (5) magnetic anomalies located along the proposed Ship Island Pass channel. Water depth in the area varies from eighteen (18) to thirty five (35) feet. Bottom sediments are silty sands.

b. Work and services to be performed under this Contract are described below.

(1) Initial investigations shall consist of reestablishment of the precise location of each anomaly to be investigated. The Contractor must identify the methodology and equipment to be employed and the schedule for completion of this task in the Technical Proposal for this Contract. Cost estimates shall be submitted separately.

(2) Following resurvey of the anomaly locations, underwater investigations shall be conducted to determine the nature, degree of preservation, and cultural significance of the anomalies. These investigations shall consist of excavation of a sufficient amount of bottom sediments to expose the materials represented by each anomaly. The materials or objects will be mapped in detail with vertical and horizontal control. Photographic/video equipment will be used to record cultural materials that are potentially eligible for the National Register of Historic Places. Equipment, personnel, and methodology to be employed in this task must be clearly discussed in detail in the Technical Proposal. Time frame for completing this task must also be detailed in the Technical Proposal. Cost estimates shall be submitted separately.

(3) The minimum quantity and variety of artifactual materials shall be recovered from the underwater excavations to permit adequate documentation of the historic significance of each anomalous area. The Technical Proposal must contain a discussion of the proposed methods of stabilization, analysis, and curation facilities to be utilized. Qualifications of personnel to conduct this phase of the project must be identified in the Organizational/Personnel section of the proposal. Schedules to complete the conservation of the various classes of artifacts must be included in the proposal.

(4) All excavations of anomalous locations will be backfilled to normal bottom contours upon completion of the underwater investigations.

(5) As a result of the underwater investigations, documentation of National Register of Historic Places eligibility shall be compiled for each significant historic property identified. At a minimum, this information shall include age and type of resource represented, previous and present ownership (if available), present and original appearance, condition, and detailed statement of significance. For example, an individual vessel may derive its significance from one or more categories such as architecture, commerce, exploration and settlement, invention, transportation or military. Historic and prehistoric archeological sites could also derive significance from more than one information category. Each identified area of significance must be thoroughly discussed in a narrative for each property. Major bibliographic references pertaining to each significant property must also be identified.

7. PERSONNEL QUALIFICATIONS:

a. Principal Investigator for the Contract shall be at the minimum an archeologist or historian at the M.A. level with at least two (2) years of professional experience in historic properties management and the administration of multidisciplinary historic properties surveys. He/she will be responsible for overall supervision of work and services to be performed under this Contract, and will be responsible for the validity of the material presented and reports produced under this Contract. The Principal Investigator shall sign the report(s). In the event of controversy or court challenge, the Principal Investigator may be placed under separate Contract and called upon to testify on the behalf of the Government in support of his findings.

b. Qualifications of the Principal Investigator and main supervisory personnel in support of their academic and experiential qualifications for the project must be submitted to the Contracting Officer by the Contractor as part of the proposal. Any change of these employees during the performance of this Contract must have the prior written approval of the Contracting Officer.

c. Historian - The minimum formal qualifications for individuals practicing history as a professional are a graduate degree in history or closely related field; or a batchelor's degree in history or closely related field plus one of the following:

(1) At least two years of full-time experience in research, writing, teaching, interpretation, or other demonstrable professional activity with an academic institution, historic organization or agency, museum, or other professional institution; or

(2) Substantial contribution through research and publication to the body of scholarly knowledge in the field of history.

d. Archeologist - The minimum formal qualifications for individuals practicing archeology as a profession are as follows:

(1) A graduate degree in archeology, anthropology, or a closely related field or equivalent training.

(2) A demonstrated ability to carry research to completion.

(3) At least sixteen (16) months of professional experience and/or specialized training in archeological field, laboratory, or library research, administration, or management, including at least four (4) months experience in archeological field research, and at least one (1) year of experience and/or specialized training in the kind of activities the individual proposes to practice. (Refer to Appendix C, 36 CFR Part 66, published in the Federal Register, Vol. 42, No. 19 - Friday, 28 January 1977, for additional information.

e. Underwater/Marine Survey Archeologist - In addition to meeting the formal qualifications for an archeologist defined above, the underwater archeologist will also have demonstrated background of coastal geomorphology and geology, familiarity with remote sensing devices such a shallow seismic

profilers, marine survey magnetometers, side scan sonar, and electronic positioning systems and the ability to interpret the output of these devices. He/she will have at least one (1) year of supervised experience in marine survey archeology, including extensive offshore training in the operation of remote sensing devices and the preparation of reports, together with at least six months in a supervisory capacity on underwater and marine survey projects. The underwater archeologist must have demonstrated knowledge and at least six months experience in the methods, techniques, and use of equipment required for underwater site evaluation and data recovery at submerged shipwreck and/or archeological sites. The underwater archeologist must also meet the qualifications for Diver described below.

f. Diver - All diving will be conducted in accordance with Occupational and Safety and Health Standards 29 CFR 1910, EM 385-1-1, and the U.S. Navy Diving Manuals, Volumes I and II. Qualifications for the various classes of divers are included in these documents.

g. Remote Sensing Technician - The minimum qualifications for remote sensing technician are at least two (2) years experience in marine geophysical survey and the ability to operate and interpret the data output of remote sensing equipment including, but not limited to: survey recording fathometer, electronic distance measuring instruments, shallow seismic profilers, marine survey magnetometers, and side scan sonar. Prior experience in the use of this equipment in underwater historic properties surveys is highly recommended.

h. Archeological Assistant - Personnel hired for this position should have a B.A. or B.S. degree in archeology, anthropology, or a closely related field. In addition, the archeological assistant should have at least three (3) months experience in field methods and laboratory analysis under the direction of a qualified underwater archeologist as defined above.

i. Consultants - Personnel hired or subcontracted for their special knowledge and expertise must possess academic and experiential qualifications in their own fields of competence. For example, a historian hired for this Contract should have demonstrated experience in maritime history, historic archeology, and naval architecture, in addition to a graduate degree in history from an accredited college or university. If consultants have not been retained at the time of contract negotiations, qualifications may be omitted until such time as they are identified, subject to written approval of the Contracting Officer.

8. SCHEDULE:

All work and services under this Contract shall be completed within nine (9) months after the date of Contract award.

9. DISMISSALS:

The Contracting Officer may require the Contractor to dismiss from work such employees as the Contracting Officer deems incompetent or careless. The Contractor shall replace at his expense any employee dismissed under the above conditions. The Contractor shall make every reasonable effort in the selection of his employees and in the prosecution of the work under this contract to safeguard all drawings, cultural materials, and other data to prevent the theft or unauthorized use of the same.

.S) 15. SUBMISSIONS/REPORTS.

a. Promptly after execution of this Contract, the Contractor shall submit to the Contracting Officer for approval, a schedule showing the order in which the Contractor proposes to carry out the work and the contemplated dates on which he will start the several salient features of the project and the contemplated dates for completing same. Such schedule shall provide for completion of all work required within the Contract time. The Contractor shall correct the progress schedule on the fifth day of each month and immediately deliver three copies to the Contracting Officer. Each progress schedule shall be accompanied by a narrative describing the work completed during the previous month.

b. The Contractor shall submit within seven (7) calendar days after a conference or discussion, either telephonic or personal, a written record for the meeting and/or discussion and furnish two copies to the Contracting Officer. The written record shall include subject, names of participants, outline of discussion, and recommendations or conclusions. Each written record shall be numbered in consecutive order.

c. Within thirty (30) calendar days of completion of the field investigations, the Contractor shall submit three (3) copies of a Management Summary which briefly and concisely summarizes the results of the investigations. This summary will include recommendations for additional data recovery/mitigation efforts for properties believed to be eligible for the National Register.

d. Within sixty (60) calendar working days a[illegible]r completion of the field investigations, the Contractor shall submit the draft report detailing the results of the study. Minimally, the report will contain the following elements: an abstract, introduction, detailed discussions of the results of the literature search, bibliography and appendices. Ten (10) copies of the draft report are to be submitted.

(1) The abstract shall be a synopsis of the report containing the general conclusions and recommendations of the study and be suitable for publication in an abstracts journal.

(2) The introduction shall include, but is not limited to, the following: source of funding, purpose of the study, delineation of the study area, personnel involved in the study, and any problems encountered in conducting the study.

(3) The study area will be placed in its regional setting, with specific attention given to previous historic properties investigations in the study area.

(4) A major component of the report shall be a discussion of how the underwater investigations were conducted and the results of these investigations. Detailed discussions of any identified properties recommended for inclusion in the National Register of Historic Places are required. The report shall contain a section detailing the proposed mitigation/data recovery plan for those properties recommended as National Register eligible that will be directly affected by channel improvements.

Estimated schedules for completion of the data recovery shall be submitted as a separate appendix to the report.

(5) The draft and final reports shall be authorized and signed by the Principal Investigator. In addition, the reports shall address the following format:

(a) Text material shall be typed on good quality bond paper, 8-1/2 inches by 11 inches with a 1-1/2 inch binding margin on the left side, 1-inch on the right, and 1-inch at the top and 1-inch at the bottom, using a type style such as 12-point type and with double line spacing for the draft report and single line spacing in the final report. No logos will appear on the text, drawings, plates, etc.

(b) Drawings or plates in the narrative report will normally not be larger than 8 1/2 inches by 11 inches with sufficient margin for binding on the left side and shall include a graphical scale. If advantageous to use plates larger than 8 1/2 inches by 11 inches and where photographic reduction or folding to 8-1/2 inches by 11 inches is not practical, the larger plates should be submitted in a separate folio, suitably identified.

(c) A copy of the Statement of Work/Specifications for this Contract will be appended to the draft report only.

(d) The cover and title page of the report must bear an appropriate inscription indicating the source of funds, the title number of the contract, the Mobile District report number, the contracting party, the author and Principal Investigator's name, if different.

(e) All references cited and/or utilized shall be listed in standard American Antiquity format. Contacts with individuals shall be cited as well. For U.S. Government funded contract reports, the reference shall note that the report was submitted to the funding agency by the preparator.

(f) Information shall be presented in textual, tabular, and graphic forms, whichever is most appropriate, effective, and advantageous to communicate necessary information.

(g) All tables shall have a number, title, appropriate explanatory notes and a source note.

(6) Black and white photographs are preferred except when color changes are important for understanding the data being presented. No Polaroid or instant type photographs may be used. Plates appearing in the report must be good quality, clear reproductions made by half-tone or equal quality process. Xerox plates are not acceptable.

d. Ten (10) copies of a draft report shall be submitted to the Contracting Officer for review by the Contracting Officer and interested State and Federal agencies sixty (60) calendar days after completion of the field investigations. Review and coordination shall be completed and comments furnished to the Contractor within sixty (60) calendar days after

receipt of the draft report. Should the Government exceed the stated review time, a corresponding extension will be granted to the Contract. Subsequent drafts may be required based on the comments of reviewers at no additional cost to the Government. Professional editing of the draft and final reports is a mandatory task.

e. Fifty (50) copies of the final report, incorporating the reviewer's comments, shall be submitted (along with a reproducible master copy of the original text, drawings, and plates) to the Contracting Officer within thirty (30) calendar days after the return of the draft report and revew comments. Perfect binding of the final reports with spine printing is mandatory.

(1) One (1) copy of the report text on disk compatible with an MS-DOS based word processor such as Multimate or Word Perfect shall be submitted with the final report.

(2) Acceptance of the final report is contingent upon written approval by the Government.

f. Neither the Contractor nor his representative shall release or publish any sketch, photograph, report, or other materials of any nature obtained or prepared under this contract without specific written approval of the Contracting Officer, prior to the final acceptance of the report by the Government.

g. A listing of records, catalog of artifacts, and other materials assembled during this Contract will be submitted as a separate document for review and approval at the same time as the draft report.

g. The report, through the Contracting Officer, will be maintained on microfiche by the National Technical Information Service (NTIS) and will be available to interested persons from NTIS. Each report will include Form DD 1473 (provided to the Contractor by the Contracting Officer) as its first page, Blocks 4, 5, 7, 8, 9, 11, 12, 13, 15, 16, 17, 19, and 20 of Form DD 1473 will be completed by the Contractor. Specific locations of sites found or otherwise identified as the result of the investigations under this contract that might be subject to vandalism will be submitted by the Contractor as a separate document apart from but with the final report and marked "Not for submission to NTIS".

16. ARCHEOLOGICAL RESOURCES PROTECTION ACT (ARPA) PERMIT

The Archeological Resources Protection Act of 1979 requires that the person performing the work described in this Statement of Work obtain an ARPA permit for such work. The finalized Contract, including the Statement of Work and the Technical Proposal will constitute the required permit in accordance with 32 CFR 229.6 and 8. In addition to the requirements stated above, the following additional information is required for ARPA purposes:

a. Written certification, signed by an authorized official of a university, museum, or other scientific or educational institute of their willingness to assume curatorial responsibility for those materials and to safeguard and preserve these materials as property of the United States.

b. A statement certifying that, not later than 90 days after the final report is submitted and accepted by the Mobile District, the following will be delivered to the appropriate official of the approved university, museum or other scientific or educational institution, which shall be named in the technical proposal: All artifacts, samples, collections, and originals of records, data, photographs, negatives, and other documents resulting from work conducted under this permit.

c. The Mobile District may require additional information and shall so inform the applicant, if required.

17. CONFERENCE AND MEETINGS

There will be two categories of meetings between Contractor and Contracting Officer: (1) scheduled formal conferences to review Contractor submissions, and (2) informal, unscheduled meetings for clarification, assistance, coordination and discussion.

a. Category (1) meetings will be scheduled by the Contracting Officer and will be held at a location to be chosen by the Contracting Officer. This may be on the project sites, but generally will be at the office of the Contracting Officer in the Mobile District office. Catagory 1 meetings will be scheduled at least every ninety (90) days after initiation of the Contract and shall equal the number of quarter years the Contract is in force.

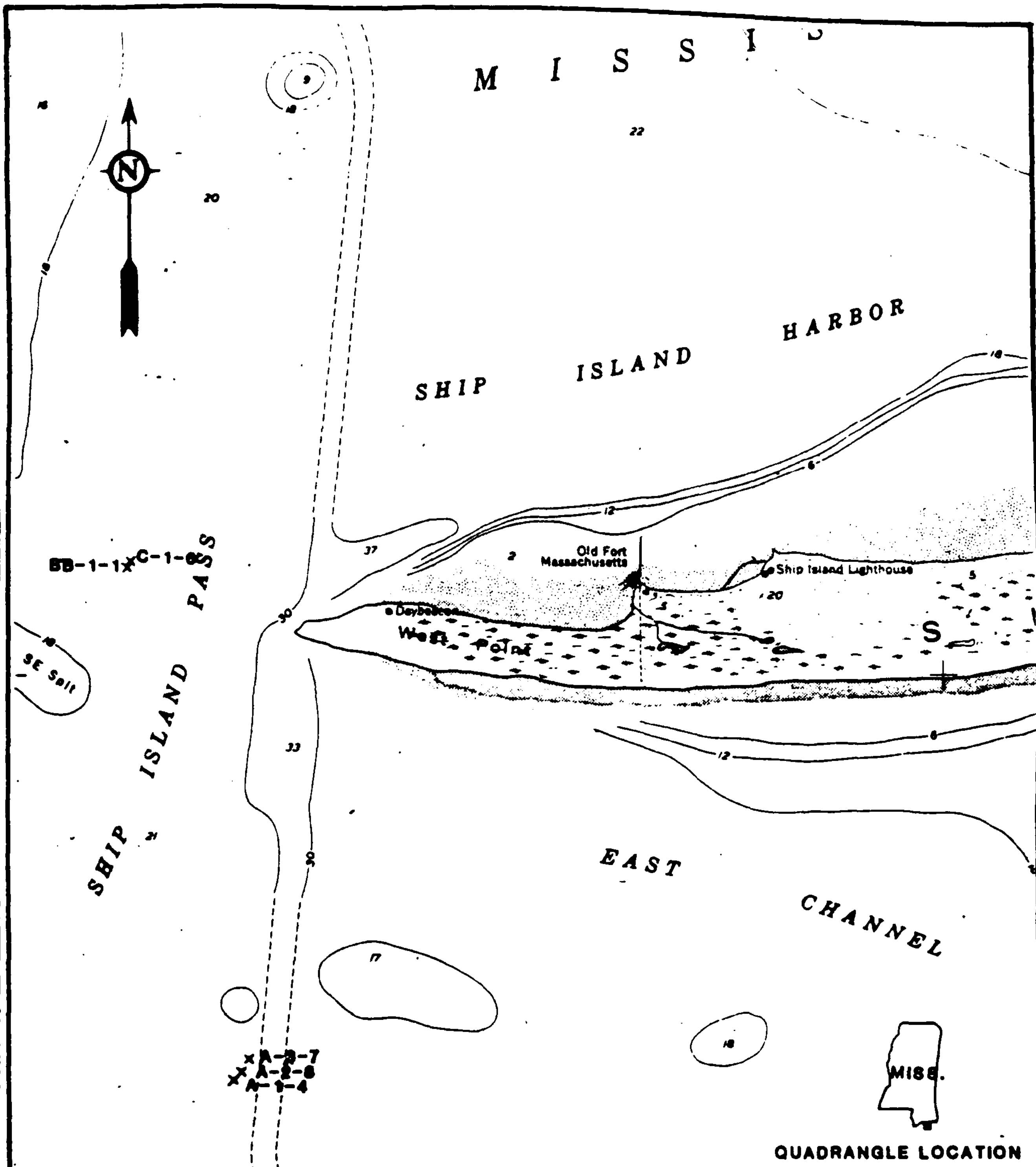
b. Category (2) meetings, if needed, may be called on short notice by the Contractor or Contracting Officer as needed during the course of the Contract for coordination, and the time and place scheduled as conveniently as possible for both.

c. Both category (1) and (2) meetings are considered a part of the contract and no extra payment will be made for attendance. The number of category (1) meetings shall not exceed a maximum of three. Category (2) meetings will be held within the vicinity of the project area.

DWG. NO. 88-354-A1

APPROVED

DRAWN: MAH

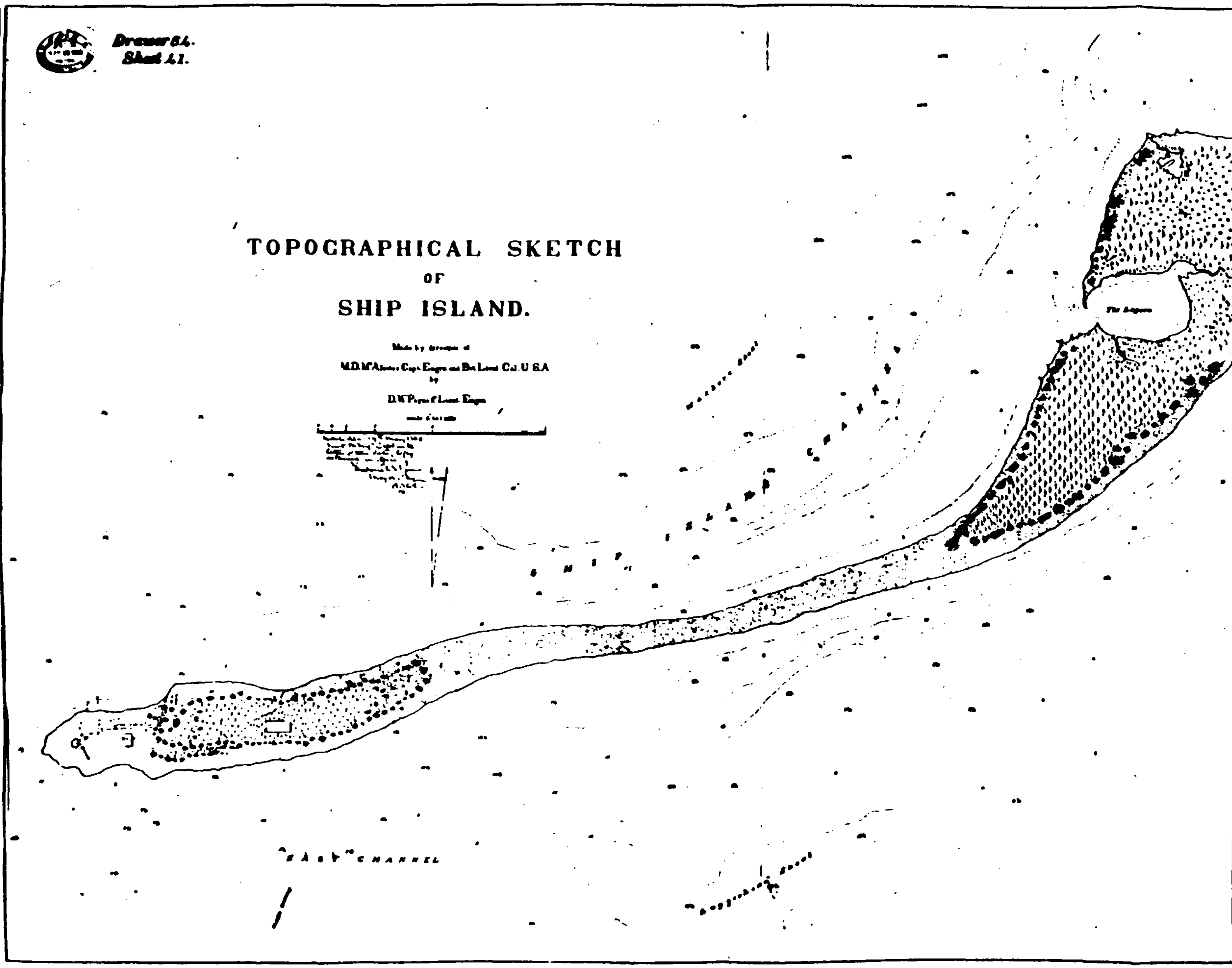


REFERENCE:
SHIP ISLAND QUADRANGLE
MISSISSIPPI
7.5 MINUTE SERIES (TOPOGRAPHIC)
PHOTOREVISED 1970

SCALE
2000 0 2000'

FIGURE 1

PROJECT AREA MAP



SOURCE:
NATIONAL ARCHIVES RG 77
DRAWER 84 SHEET 41

FIGURE 2

SHIP ISLAND
FROM A TOPOGRAPHICAL
MAP OF 1868

DWN. RWM
APPROVED
DWG. NO

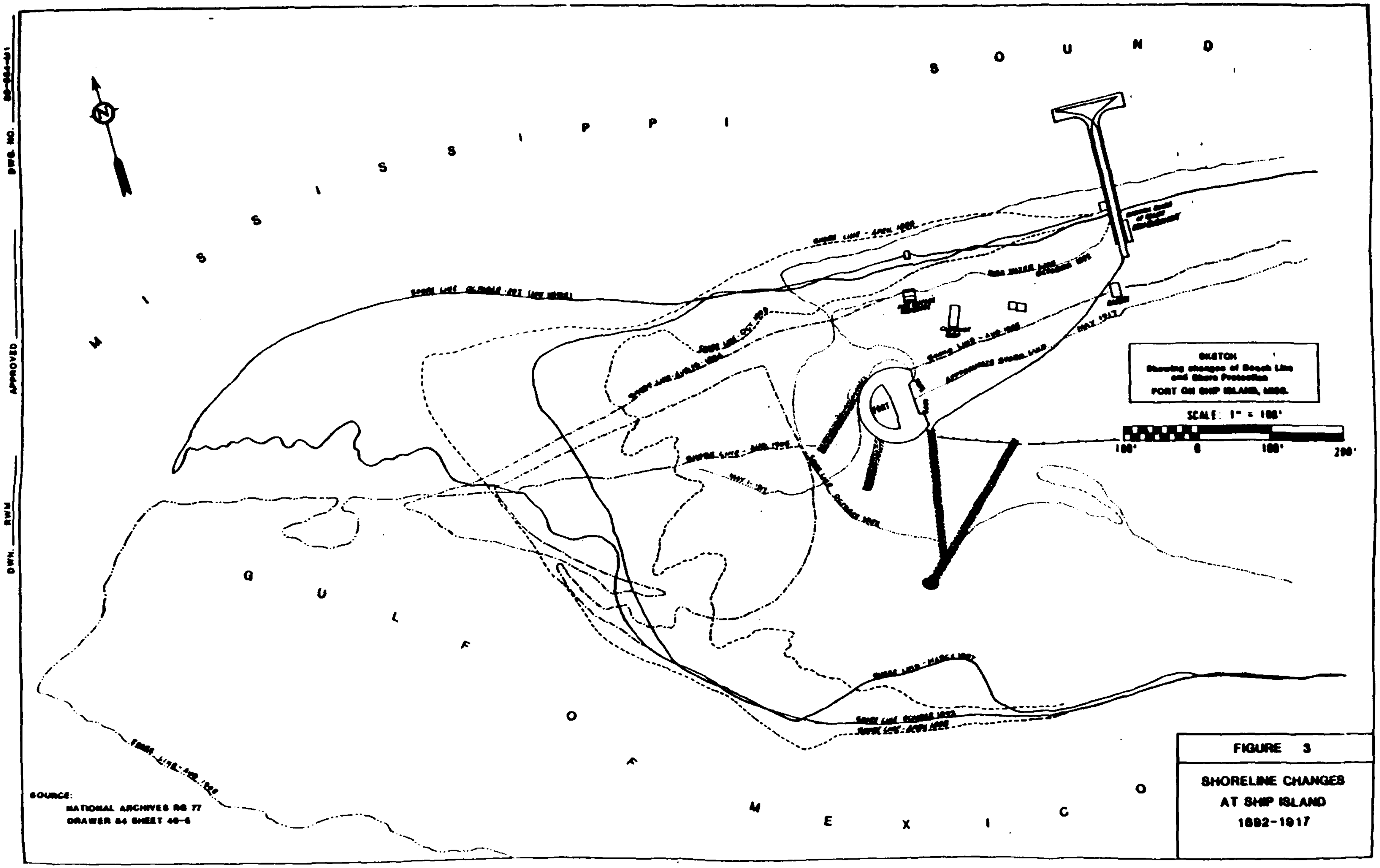


FIGURE 3

SHORELINE CHANGES AT SHIP ISLAND 1892-1917

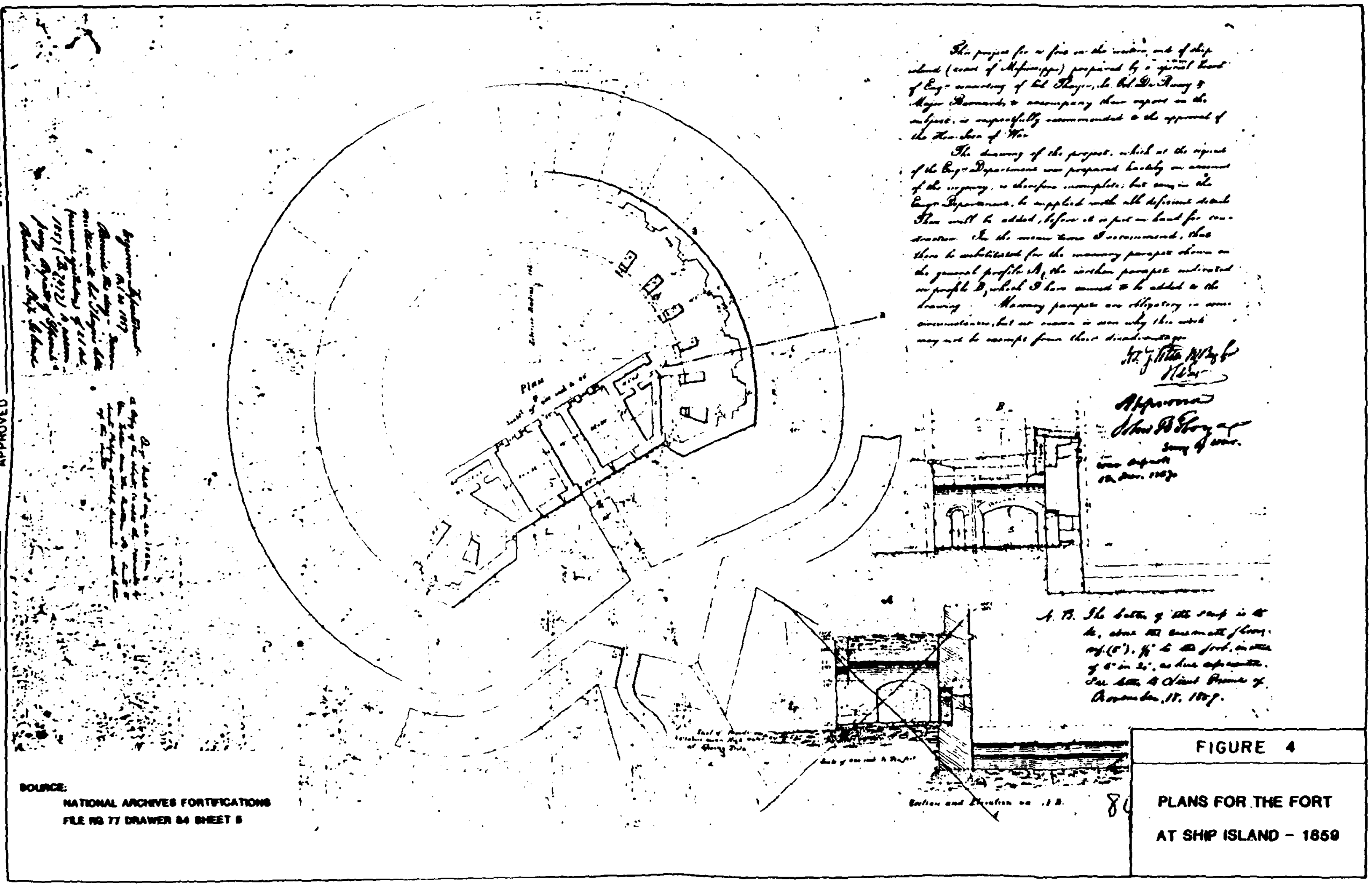
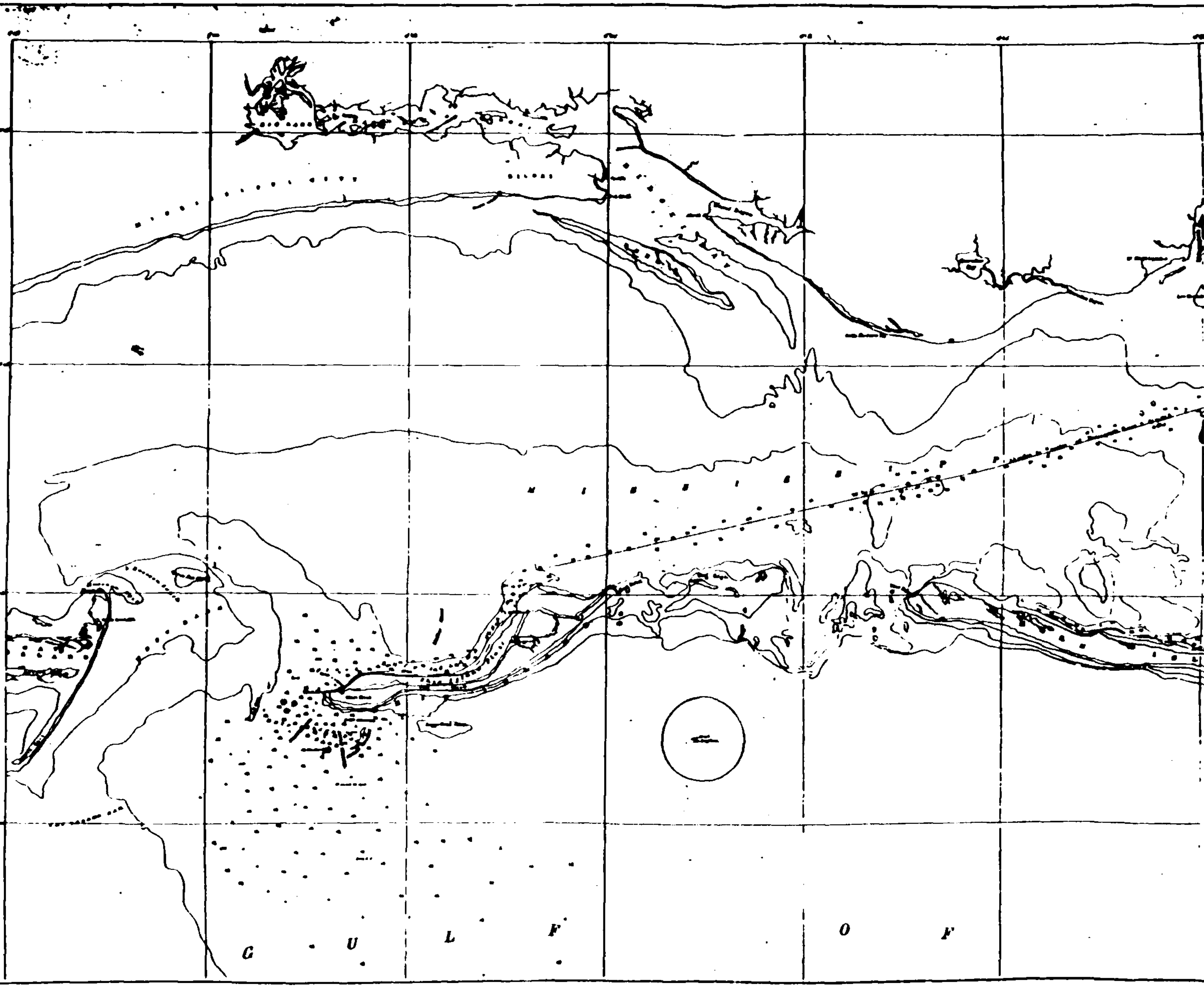


FIGURE 4

PLANS FOR THE FORT AT SHIP ISLAND - 1859

SOURCE:
NATIONAL ARCHIVES FORTIFICATIONS
FILE RG 77 DRAWER 84 SHEET 5

DWN. RWM APPROVED DWG. NO

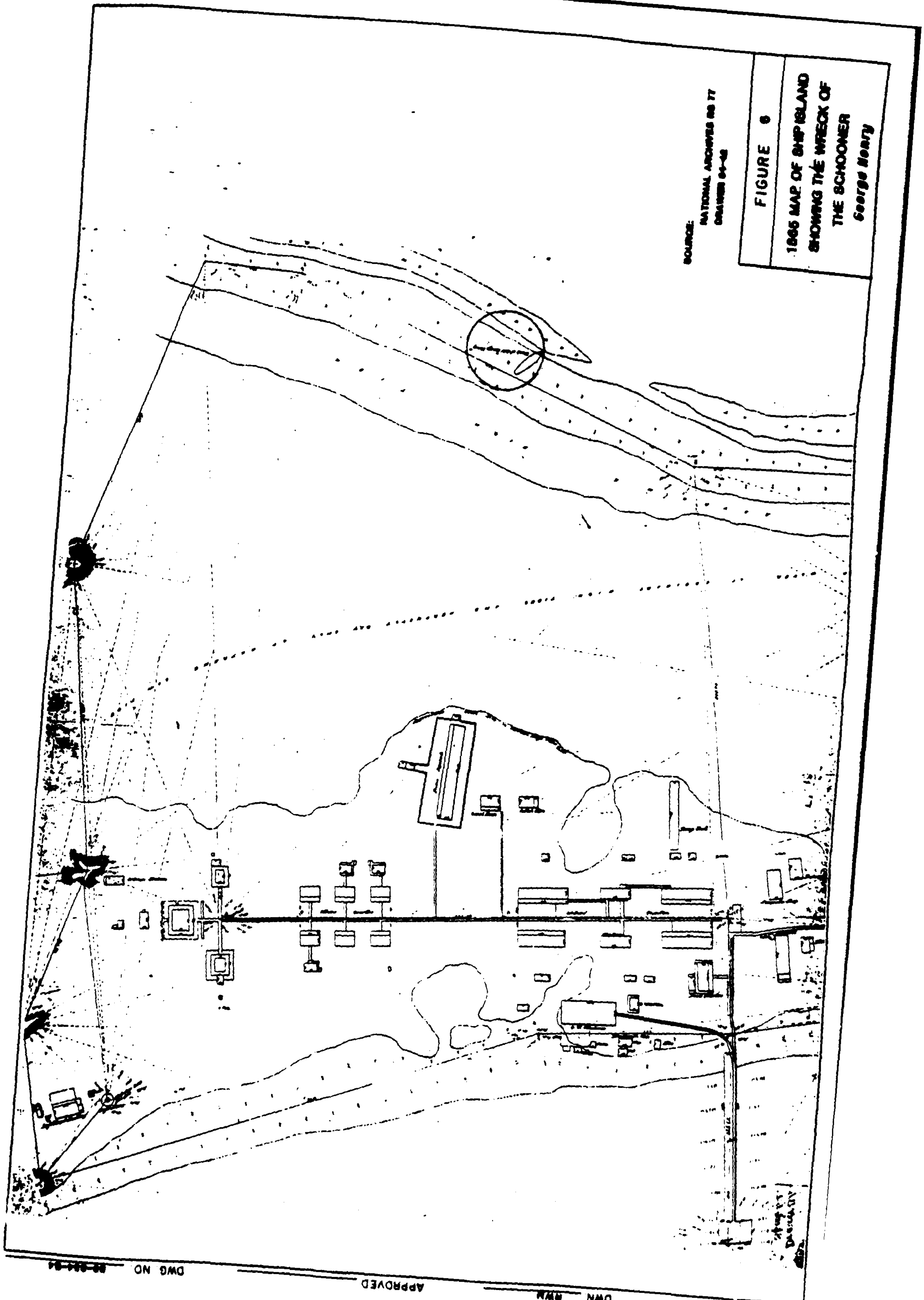


SOURCE:
NATIONAL ARCHIVES RG77 S-47

FIGURE 5

1881 MAP OF THE OUTLET OF THE HARBOR AT SHIP ISLAND SHOWING THE WRECK OF THE *Josephine*

DWN RWM APPROVED DWG. NO



SOURCE:
NATIONAL ARCHIVES RG 77
DRAWER 94-46

FIGURE 6

1865 MAP OF SHIP ISLAND SHOWING THE WRECK OF THE SCHOONER *George Henry*

SECTION D-6

SECTION 404 (b)(1) EVALUATION FOR

AUTHORIZED NAVIGATION IMPROVEMENTS AT

GULFPORT, MISSISSIPPI

Section 404(b)(1) Evaluation
For
Gulfport Harbor, Mississippi
Navigation Improvements

Introduction. The proposed plan to provide navigation improvements at the Gulfport Harbor Project requires the deepening of the turning basin, the existing channel alignments in Mississippi Sound and the Gulf of Mexico, the deepening of the Ship Island Pass Channel segment along a new alignment from the Gulf of Mexico to the Mississippi Sound Channel, and the disposal of materials dredged from these channels. For ease of presentation of the Section 404(b)(1) Evaluation, the discussion of the materials to be disposed is divided into two categories: A) materials dredged from the Ship Island Pass Channel and B) materials dredged from the Mississippi Sound channel and turning basin.

A(I). **PROJECT DESCRIPTION.** Materials to be removed from the Ship Island Pass Channel would be disposed in shallow water in the vicinity of the southeastern end of Cat Island (Figure 404-1). Approximately 2,589,700 cubic yards of new work material and a total of 22,685,050 cubic yards of maintenance material would be disposed in this area over the life of the project. Some of this material could also be utilized for beach nourishment at Fort Massachusetts as requested by the National Park Service. See pages EIS-10 - EIS-17 of the final EIS for a more detailed description of the proposed plan.

a. **Authority and Purpose.** Authority for this study is contained in Senate Public Works Committee Resolution adopted on September 23, 1965. This resolution requested that the Board of Engineers for Rivers and Harbors determine the advisability of modifying Gulfport Harbor. Further, Section 304 of the River and Harbor Act of 1965 authorized and directed the Secretary of the Army to begin survey scope studies. Preparation of a combined report was requested by the Chief of Engineers on October 4, 1965.

The draft survey report, including draft Environmental Impact Statement, was coordinated in June 1976 and subsequently revised in July 1977 and December 1977. This report was transmitted to Congress in November 1978 and recommended the authorization of Phase I design memorandum stage of advance engineering and design be accomplished rather than construction. Studies to be conducted during Phase I investigations would determine which of the alternatives would be implemented should the project be authorized (USACE 1976). The final EIS would be prepared after conclusion of the Phase I studies. Improvement of the Gulfport Harbor navigation project was initially authorized by the Fiscal Year 1985 Supplemental Appropriations Act (P.L. 99-88) in accordance with the 1976 Report and subsequently modified by The Water Resources Development Act of 1986 (P.L. 99-662).

Section 202 (a) of P.L. 99-662 authorizes for construction: "The project for navigation, Gulfport Harbor, Mississippi: Report of the Chief of Engineers, House Document Numbered 96-18, at a total cost of $81,700,000,

with an estimated first Federal cost of $61,100,000 and an estimated first non-Federal cost of $20,600,000; except that, for reasons of environmental quality, dredged material from such project shall be disposed of in open water in the Gulf of Mexico in accordance with all provisions of Federal law. For the purpose of economic evaluation of this project the benefits from such open water disposal shall be deemed to be at least equal to the costs of such disposal". The Water Resources Development Act of 1988 (P.L. 100-676) further modified the authorized project to include: " ... to dispose, in accordance with all provisions of Federal law, of dredged material ...

(B) from construction of such project by thin layer disposal in the Mississippi Sound under the demonstration program carried out under paragraph (2);

(C) from operation and maintenance of such project by disposal in the Mississippi Sound under a plan developed by the Secretary and approved by the Administrator of the Environmental Protection Agency, if the Secretary, after consultation with the study team established under paragraph (3), determines that the report submitted under paragraph (2)(H) indicates that there will be no unacceptable adverse environmental impacts from such disposal ..."

b. **Description of the Proposed Dredged and Fill Materials from the Ship Island Pass Channel.**

(1) General characteristics. The fill material that would be placed in the subtidal or beach nourishment site consists of naturally occurring sand.

(2) Quantity of material proposed for discharge. Approximately 2,589,700 cubic yards of new work and a total of 22,685,050 cubic yards of maintenance material dredged from the Ship Island Pass Channel would be disposed over the life of the project.

(3) Source of materials. The dredged material would be obtained by dredging the Ship Island Pass channel which is approximately 5,000 feet east of the proposed littoral zone disposal site and west of the proposed beach nourishment site.

c. **Description of the Proposed Discharge Site.**

(1) Location and areal extent. The littoral zone site is located in the Gulf of Mexico southeast of Cat Island, Mississippi, and occupies approximately 1000 acres of subtidal habitat in 14 to 20 feet of water. The beach nourishment site is located on the northwest end of West Ship Island in the vicinity of Fort Massachusetts and occupies approximately 60 acres. The beach nourishment site has been used in the past, with the last use occurring in 1983.

(2) Type of discharge site. The littoral zone discharge site is typical of the nearshore Gulf of Mexico with predominately marine sand

substrate. The beach nourishment site for erosion control at Fort Massachusetts includes approximately 5,000 feet of beach and adjacent shallow waters.

(3) Method of discharge. The material could be placed in the littoral zone site utilizing hydraulic pipeline/cutterhead dredge, hopper dredge or split hull hopper barges. Material could be placed on the beach nourishment site utilizing hydraulic pipeline/cutterhead dredge or hopper dredge with pumpout capability.

(4) When would disposal occur? New Work disposal is scheduled to begin in 1991. Maintenance disposal would typically be on a 12 - 18 month cycle thereafter.

(5) Projected life of discharge site. The projected life of the littoral zone disposal site is considered indefinite but at least 50 years. The material is being placed in this site so that it will become part of the littoral drift system which nourishes Cat Island and the Chandeleur Islands. Future use of the beach nourishment area on Ship Island will depend on future needs as identified by the National Park Service.

A(II). **FACTUAL DETERMINATIONS.**

a. **Physical Substrate Determinations.**

(1) Substrate elevation and slope. The disposal of dredged material in the littoral zone site may result in some mounding, however the wave climate on the Gulf shore of Cat Island is such that this should not pose a significant impact to the resources of the island or circulation in the nearshore Gulf of Mexico. Disposal in the beach nourishment site will result in increases in elevation in the area. The deposited material will be "worked" by waves and currents to emulate natural shoreline conditions.

(2) Sediment type. Mineral composition and particle size of the substrate would not be altered.

(3) Dredged or fill material movement. The dredged material is expected to be transported in the littoral drift system of the nearshore Gulf of Mexico. This movement however, would not have any adverse impact on the area and could result in nourishment of Cat Island. Material eroding from the beach nourishment site would be trapped by the old Ship Island Pass Channel, which will be allowed to fill in.

(4) Physical effects on benthos. The disposal of the dredged material would disrupt the benthic community of the disposal site during placement, however the community should reestablish within 6 to 12 months after the disposal occurs. The communities present in these areas are adapted to very rigorous conditions associated with wave and storm induced sediment movement.

(5) Actions taken to minimize impacts. Since the material to be disposed is naturally occurring sand and the substrate of the disposal site

is sand, no further actions are deemed necessary.

b. **Water Circulation, Fluctuation and Salinity Determinations.**

(1) Water. There would be no significant impacts on water chemistry, color, odor, taste, dissolved gas levels, nutrients or eutrophication characteristics due to dredging or disposal. Water clarity may be temporarily reduced during the dredging and disposal activities but should return to normal shortly after construction is completed.

(2) Current patterns and circulation. The disposal would not result in any change in current patterns or circulation.

(3) Normal water level fluctuations. There would be no change in normal water level fluctuations.

(4) Salinity gradients. There would be no change in salinity patterns or gradients.

c. **Suspended Particulate/Turbidity Determinations.**

(1) Expected changes in suspended particulates and turbidity levels in vicinity of disposal site. Short-term increases in suspended particulate levels may occur at the time of dredging and disposal. However, due to the nature of the material to be disposed these increases would be within the normal range of fluctuation of these parameters for this area of the nearshore Gulf of Mexico and would not violate state water quality standards.

(2) Effects on chemical and physical properties of the water column. Slight decreases in the degree of light penetration and dissolved oxygen concentration may occur during disposal and dredging activities.

(3) Effects on biota. Effects would be insignificant since the biota of this area are adapted to the naturally turbulent nature of the nearshore zone.

(4) Actions taken to minimize impacts. Due to the nature of the material to be disposed and the energy regime of the disposal site the impacts would be minimal. Efforts would be made to schedule disposal at times when utilization of the area by sea turtles is not evident.

d. **Contaminant Determinations.** The material has been determined to meet the criteria set forth in 40 CFR 230.60(b) in that the material is characterized as sand which is sufficiently removed from sources of pollution to provide reasonable assurance that the material would not be contaminated by such pollution and the fact that the material itself is inert. Also the material originates in the near vicinity of the disposal activity, is similar to the substrate of the disposal site, and receives the same overlying waters as the disposal site. Hence, no further physical, biological, or chemical testing is required pursuant to the 404(b)(1) Guidelines.

e. **Aquatic Ecosystem and Organism Determinations.**

(1) Effects on plankton. Disposal of dredged material into open water would destroy some phytoplankton and zooplankton, and could reduce light penetration which may tend to affect primary production by the phytoplankton. Due to the nature of the materials to be disposed, these impacts would not be significant.

(2) Effects on benthos. Open water disposal of the sandy material could smother some of the benthos of the proposed site, however these organisms are adapted to a very rigorous environment in which they experience wave and storm induced sedimentation and the impacts due to the disposal would not be significant.

(3) Effects on nekton. Some members of the nektonic community in and around the open water disposal area would probably vacate the area, at least until conditions become more favorable. All such organisms would not be expected to vacate; however, it is logical to assume that many would avoid an area of disturbance such as that associated with discharge of dredged material. Some nektonic filter feeders may be killed as a result of being in the affected area and other organisms less capable of movement, such as larval forms, may be physically covered with dredged material. Generally, however, most organisms would avoid and later return to the project area.

(4) Effects on aquatic food web. No significant effects.

(5) Effects on special aquatic sites.

(a) Sanctuaries and refuges. The proposed disposal of dredged material would not significantly affect any of the fish and wildlife resources which are designated for preservation or general use in the 1980 Mississippi Coastal Program.

(b) Wetlands. No wetlands would be filled during the proposed activity.

(c) Mud flats. No significant effects.

(d) Vegetated shallows. No significant effects.

(e) Coral reefs. Not applicable to this area.

(f) Riffle and pool complexes. Not applicable to this area.

(6) Threatened and endangered species. The Fish and Wildlife Service provided a list of 20 species which may occur in the study area including the Florida manatee, Florida panther, 5 species of whales, the bald eagle, peregrine falcon, brown pelican, Bachmann's warbler, ivory-billed and red-cockaded woodpeckers, American alligator, eastern indigo snake, and 5 species of sea turtles. The National Marine Fisheries Service indicated that the five species of whales and five species of marine turtles

may be present. The majority of the species listed by the Fish and Wildlife Service are restricted to upland areas. Exceptions include the Florida manatee which only occasionally wanders into this area of the Gulf and the American alligator which prefers swamps, lakes, sloughs, and sluggish streams along the mainland. Whales are primarily restricted to open gulf waters and therefore would not be impacted by implementation of the recommended plan. Sea turtles may occur within the Mississippi Sound and may nest on the gulf beaches of the barrier islands. Of prime importance is the Kemp's (Atlantic) ridley turtle which is considered to be the most endangered of the species listed for this area. This turtle is known from the Mississippi Sound and is typically associated with shallow vegetated habitats. The recommended plan does not require dredging or disposal near any shallow vegetated habitats therefore no impacts to this species are expected to occur. The other species occur less frequently within the sound and therefore would not be impacted by the proposed action. Concurrence with this finding was requested from the U.S. Fish and Wildlife Service (FWS) and the National Marine Fisheries Service (NMFS) on November 1, 1988. The FWS, in the final Fish and Wildlife Coordination Act Report dated November 10, 1988, indicated that no impacts would occur to endangered species but that coordination should continue since additional species may be listed in the future. By letter dated May 26, 1989, the NMFS concurred with the determination that species under their purview would not be adversely affected by the proposed action (See Section 8, Appendix D).

(7) Other wildlife. No significant effects.

(8) Actions to minimize impact. Construction boat operators would be instructed to keep a lookout for sea turtles and should any be sighted appropriate coordination efforts with the National Marine Fisheries Service would be initiated immediately and a coordinated effort be made to avoid impacts to these species.

f. **Proposed Disposal Site Determinations.**

(1) Mixing zone determination. The State of Mississippi determines mixing zones on a case-by-case basis. For similar disposal activities, the State has established a mixing zone of 750 feet. Turbidity increases of 50 JTU's above background levels beyond a 750-foot mixing zone would not occur due to the nature of the material to be disposed.

(2) Determination of compliance with applicable water quality standards. This area of the nearshore Gulf of Mexico is classified for recreational use and shellfish harvest. The disposal operation would not alter constituent concentrations established for this use, and would not violate other State Water Quality Standards.

(3) Potential effects on human use characteristic. The disposal operation would not adversely affect any of the human use characteristics of the area. Cat Island is currently experiencing erosion on the eastern face and the southeast tip. The disposal activity would help to reduce the rate of erosion of the eastern end of the island thereby helping to maintain the island as naturally functioning barrier. Fort Massachusetts, a National

Historic Site, has experienced erosion in the past. Continuing beach nourishment in this area will help to preserve this site for future generations.

(a) Municipal and private water supply. No significant effects.

(b) Recreational and commercial fisheries. Some impacts to fish and wildlife resources could occur depending upon timing of dredged material placement in open water, however these are not considered to be significant.

(c) Water-related recreation. No significant effects.

(d) Aesthetics. Dredging in late fall to early winter would miss the peak recreational season however it may not be possible to schedule the disposal activities during this time due to weather and the time required to complete the activities would be longer than this period. The presence of the dredge, dredge pipe, and associated water and land based equipment would be evident and would temporarily degrade aesthetic qualities of the area.

(e) Parks, national and historic monuments, national seashores, wilderness areas, research sites, and similar preserves. Use of the beach nourishment area at Fort Massachusetts would be accomplished at the request of the National Park Service.

g. **Determination of Cumulative Effects on the Aquatic Ecosystem.** Cumulative effects of the disposal action would be positive in that the rate of erosion of the eastern end of Cat Island should be reduced over the life of the project. Beneficial impacts of helping maintain the position of the island include protection of mainland shores, protection of seagrass beds along the northern shore of the island, and protection of wildlife and shorebird habitat. Should excessive or rapid shoaling of the open water site occur during the 50-year project life, modifications in disposal practices or disposal site use would be addressed.

h. **Determination of Secondary Effects on the Aquatic Ecosystem.** Secondary effects of the discharge operation would be in terms of maintenance of Cat Island and its effects on the overall nearshore community. This should result in increased stability of the ecosystem which in turn would result in increased productivity.

B(I). **PROJECT DESCRIPTION.** Approximately 1.5 million cubic yards of material dredged from the turning basin will be disposed adjacent to the west port facility during expansion by the Port of Gulfport under a Department of the Army permit. Approximately 1 million cubic yards of new work material from the Mississippi Sound channel would be disposed in three locations on the east side of the channel during the thin layer demonstration program as authorized in the Water Resources Development Act of 1988 (P.L. 100-676). The disposal of material associated with the thin

layer demonstration project would occur during three separate ten day events, one during early spring, one in mid-summer, and one in fall. Material dredged during the future maintenance of the turning basin and Mississippi Sound channel would be disposed in open water sites along the channel in Mississippi Sound as is currently practiced. Approximately 3.5 million cubic yards would be placed in these sites on an 18-month cycle. A demonstration program has been developed in consultation with a Study Team composed of the local sponsor and state and Federal environmental agencies. The duration of this program is three years and will investigate the impacts associated with the thin layer disposal of new work and maintenance dredged material. The study plan is currently being finalized and will be provided to all interested parties upon completion. The demonstration program and a discussion of the coordination aspects associated with the development of the plan are included in Appendix D-9. Also included is a summary of the discussions of the February 21-22, 1990 meeting concerning fish research needs for the demonstration project.

a. **Authority and Purpose.** Same as A(I) above (Page D-6-1).

b. **Description of the Proposed Dredged and Fill Materials from the Mississippi Sound Channel and Turning Basin.**

(1) General characteristics. The new work dredged material is classified as plastic clays, poorly graded sands, and silty sands. From the harbor to the Gulf Intracoastal Waterway it's typical to find six to eight feet of the clay overlying the sandy soils. Most of the clays encountered were soft to very soft, however firm clay was encountered in at least two locations. The maintenance material consists primarily of inorganic silts and clays with a liquid limit of 50 percent or less with some silty sands. The maintenance material which accumulates in the channel results from the shoaling due to the east-to-west current patterns within Mississippi Sound, sloughing of adjacent bottom areas, and dredged material re-entering the channel. The General Design Memorandum, Appendix C and Final EIS contain further details on the characteristics of the material proposed for disposal.

(2) Quantity of material proposed for discharge. Approximately 1,500,000 cubic yards of new work material will be discharged during the port expansion activities. One million cubic yards of new work material would be discharged into three specified open water sites during the thin layer demonstration program. Approximately 3.5 million cubic yards of maintenance material would be discharged into the open water sites each maintenance cycle. This quantity varies from cycle to cycle depending on shoaling conditions within the channel.

(3) Source of materials. Material to be utilized during port expansion activities will originate from the turning basin area. The new work dredged material would be taken from the channel immediately adjacent to the demonstration program disposal areas. The maintenance material would originate in the turning basin and Mississippi Sound Channel south to the vicinity of Ship Island Pass.

c. **Description of the Proposed Discharge Site.**

(1) Location and areal extent. The proposed port expansion site includes 29 acres just seaward of the western port facilities. The remaining proposed disposal sites include open water sites located along both sides of the ship channel (2,500 feet from the channel and 1,000 feet apart) and must be deeper than four feet below MLW. All open water sites have been previously used many times for dredged material disposal. Three of the sites, approximately 300 acres, each on the east side of the channel will be utilized for the disposal of the new work material. Maintenance material disposal will be restricted to the west side of the channel until the demonstration program is complete. Approximately 4,460 acres of water bottoms have been designated as open water disposal sites for the existing Gulfport Harbor project, however, not all of these areas are impacted with each maintenance operation. Approximate acreage occurring in each disposal area, 1 through 10, are 280, 370, 370, 770, 540, 410, 640, 390, 230, and 460 acres, respectively (Figure 404-2).

(2) Type of discharge site. The port expansion site in Mississippi Sound is immediately adjacent to port facilities and ranges in depth from 0 to 9 feet MLW. Sites 1 through 10 are currently used open water sites within the Mississippi Sound and range in depth from 4.5 feet MLW to 10 feet MLW. These sites are typical of western Mississippi Sound with substrates composed predominately of silt and clay with varying percentages of sand. These sites were the subject of a 404(b)(1) Evaluation prepared in November, 1979, for the operation and maintenance of the existing project. Water quality certification was granted in 1979, again in 1984, and was requested for another 5 year period in May 1989.

(3) Method of discharge. The material would be placed in the sites utilizing mechanical and/or hydraulic pipeline/cutterhead dredges.

(4) When would disposal occur? New Work disposal is scheduled to begin in 1991 and is restricted to three 10 day periods. One 10 day period is scheduled in early spring, one in mid-summer, and one in the fall. Maintenance disposal would typically be on a 18 month cycle thereafter, depending upon shoaling patterns within the channel.

(5) Projected life of discharge site. The projected life of the port expansion area is one year. The projected life of all the openwater disposal sites is indefinite but for at least 50 years. The use of the sites is evaluated every 5 years for compliance with State Water Quality Certification. The project life of the disposal areas for the demonstration project is 10 days. Disposal in the demonstration sites will be prohibited until the demonstration project has been completed and the required reports transmitted to Congress.

B(II). **FACTUAL DETERMINATIONS.**

a. Physical Substrate Determinations.

(1) Substrate elevation and slope. Fill into the proposed port expansion area will raise this area to elevations commensurate with adjacent port facilities. The thickness of the new work material proposed for disposal in Mississippi Sound will be limited to no greater than 12 inches. Studies performed in Gulfport in the past (WAR 1975) indicated that the maximum accumulation of maintenance dredged material was 12 inches. Our goals for future maintenance dredged material will also be a thickness of 12 inches. Bathymetric surveys in 1978 indicated that the only open water site that had significant dredged material accumulation was Site 1 and it was felt that much of this accumulation evidenced in this area was the result of non-Federal new work disposal. Additional surveys of this area (1980, 1982, and 1984) indicated that no additional shallowing had occurred. We will continue to monitor this area and should depths begin to decrease toward the -4-foot MLW limit disposal would be stopped. Questions were raised in 1984 concerning depths in Sites 2 and 3, however comparison of 1980 and 1984 surveys show a trend toward deepening in these sites instead of shallowing. We will continue to monitor these sites as well.

(2) Sediment type. The port expansion area would be covered with pavement. Mineral composition and particle size of the substrate at the other sites would not be altered. Studies of maintenance dredging at Gulfport showed no affect on grain size or sorting characteristics between the disposal sites and adjacent areas.

(3) Dredged or fill material movement. The port expansion area will be confined therefore no movement of material from this area will occur. Movement of the dredged material from the other sites is probably limited to a few months after deposition, as the material begins to dewater and consolidate. In the Gulfport study referred to above, it was interesting to note that much of the redistribution of dredged material was due to shrimp boats trawling on the disposal areas. Questions concerning the potential for resuspension of recently deposited dredged materials will be addressed in the demonstration project.

(4) Physical effects on benthos. The benthos of the port expansion area will be destroyed. The disposal of the dredged material into the other open water sites would disrupt the benthic community of the disposal site during placement, however the community should reestablish within 6 to 12 months after the disposal occurs. Benthic community studies performed during Mississippi Sound and Adjacent Areas Study (Vittor, 1984) indicated no dissimilarity between historically used disposal sites and adjacent non-disposal areas. A short-term thin layer disposal study at Gulfport indicated recolonization of the disposal site begins as early as 6 weeks after disposal in winter and that within 20 weeks there were no significant differences between the disposal and reference areas (TAI 1988). Additional information concerning the long-term impacts of disposal of maintenance dredged materials and new work material will be provided during the demonstration project.

(5) Actions taken to minimize impacts. Impacts due to the port expansion will be mitigated. Dredged material thickness will be restricted to 12 inches or less. Since the material to be disposed is similar to that of the disposal area no further actions are deemed necessary. Should the results of the demonstration project show unacceptable impacts additional actions to minimize impacts will be determined.

b. **Water Circulation, Fluctuation and Salinity Determinations.**

(1) Water. There would be no significant impacts on water chemistry, color, odor, taste, dissolved gas levels, nutrients or eutrophication characteristics due to dredging or disposal. Water clarity may be temporarily reduced during the dredging and disposal activities but should return to normal shortly after construction is completed. To further elucidate the level impacts of disposal on these parameters a water quality monitoring program is being implemented as part of the demonstration program.

(2) Current patterns and circulation. The disposal would not result in any change in current patterns or circulation. These impacts were investigated utilizing a numerical model during the Mississippi Sound and Adjacent Areas Study (USACE 1984). Localized changes in current velocities were associated with the improvement of the channel but not with the proposed disposal action. The greatest changes in current patterns and circulation in western Mississippi Sound were associated with the opening of the cut (Camille Cut) in Ship Island during Hurricane Camille in 1969.

(3) Normal water level fluctuations. There would be no change in normal water level fluctuations.

(4) Salinity gradients. There would be no change in salinity patterns or gradients. Localized changes in salinity within the channel were detected during the modelling efforts described in b.(2) above. No salinity changes were detected due to the proposed open water disposal operations.

c. **Suspended Particulate/Turbidity Determinations.**

(1) Expected changes in suspended particulates and turbidity levels in vicinity of disposal site. Short-term increases in suspended particulate levels may occur at the time of dredging and disposal. However, due to the naturally turbid nature of Mississippi Sound these increases would be within the normal range of fluctuation of these parameters for this area and would not violate state water quality standards. Although the placement of 1,000,000 cubic yards of new work material during the demonstration program may result in elevated levels of suspended particulates and increased turbidity levels, the restriction of the operation to three temporally and spatially separate areas within the Mississippi Sound is believed to provide adequate protection to the resources of Mississippi Sound. Detailed investigation of suspended solid levels around the discharge point and the relationship of this disposal option to State Water Quality Standards are a significant portion of the water quality monitoring program.

(2) Effects on chemical and physical properties of the water column. Slight decreases in the degree of light penetration and dissolved oxygen concentration may occur during disposal and dredging activities. The level of these impacts and the response of significant biological resources to these impacts will be monitored during the demonstration program.

(3) Effects on biota. The effects of the disposal operation on biota of the area are not expected to be significant. Many adult forms such as finfish, shrimp, crabs etc. are expected to avoid areas of high turbidity. Effects on larval forms are not as well understood. Laboratory studies are being developed to determine the direct (gill clogging by suspended particulates) and indirect (reduction of predation/feeding) effects of elevated levels of suspended particulates or increases in turbidity. Control field studies will also be implemented during the demonstration project at Gulfport to determine effects on adult forms.

(4) Actions taken to minimize impacts. No specific actions are being taken at this time, however based on the results of the demonstration program recommendations may be made which would further reduce impacts from suspended particulates or turbidity in the vicinity of the disposal site.

d. **Contaminant Determinations.** The material has been subjected to biotoxicity and bioaccumulation tests as required by the Marine Protection, Research, and Sanctuaries Act. Results of these tests are presented in Sections 3 and 4 of Appendix D to the General Design Memorandum and are summarized in the FEIS. As a result of these tests the material has been determined to meet the criteria for ocean disposal. In addition, the material originates in the near vicinity of the proposed open water disposal activity, is similar to the substrate of the disposal sites, and receives the same overlying waters as the disposal site. Therefore, no further testing of the material was performed.

e. **Aquatic Ecosystem and Organism Determinations.**

(1) Effects on plankton. Disposal of dredged material into open water would destroy some phytoplankton and zooplankton, and could reduce light penetration which may tend to affect primary production by the phytoplankton. Laboratory studies are being designed to determine the direct and indirect effects of the disposal on larval fish. These will be implemented during the demonstration program.

(2) Effects on benthos. Benthos within the proposed port expansion area will be destroyed. Open water disposal of the dredged material in the other proposed sites will smother some of the benthos, however studies have indicated that these organisms begin recolonization of the disposal area in as little as 6 weeks and that full recovery may occur within 20 weeks after disposal. Additionally, some forms of the benthos are able to up migrate through the dredged material, especially if it is placed in thin layers such as is proposed here. The overall effects on the benthos is not considered to be significant. Additional studies relative to long-term impacts and impacts to meiobenthic forms will be performed as part of the demonstration program.

(3) Effects on nekton. Due to the size and location of the proposed port expansion area, effects on nekton due to this action will be limited. Some members of the nektonic community in and around the open water disposal area would probably vacate the area, at least until conditions become more favorable. All such organisms would not be expected to vacate; however, it is logical to assume that many would avoid an area of disturbance such as that associated with discharge of dredged material. Some nektonic filter feeders may be killed as a result of being in the affected area and other organisms less capable of movement, such as larval forms, may be physically covered with dredged material. Although some forms may move from the affected area, impacts may still occur from increased competition in other areas of the sound or from changes in feeding patterns. Controlled field studies are being designed to investigate these issues as part of the demonstration program.

(4) Effects on aquatic food web. No significant effects on the aquatic food web of Mississippi Sound would occur from the implementation of the recommended plan. Only a small portion of the Mississippi Sound would be impacted at any one time during construction of the project.

(5) Effects on special aquatic sites.

(a) Sanctuaries and refuges. The proposed disposal of dredged material would not significantly affect any of the fish and wildlife resources which are designated for preservation or general use in the 1980 Mississippi Coastal Program.

(b) Wetlands. No wetlands would be filled during the proposed activity.

(c) Mud flats. No significant effects.

(d) Vegetated shallows. No significant effects.

(e) Coral reefs. Not applicable to this area.

(f) Riffle and pool complexes. Not applicable to this area.

(6) Threatened and endangered species. The Fish and Wildlife Service provided a list of 20 species which may occur in the study area including the Florida manatee, Florida panther, 5 species of whales, the bald eagle, peregrine falcon, brown pelican, Bachmann's warbler, ivory-billed and red-cockaded woodpeckers, American alligator, eastern indigo snake, and 5 species of sea turtles. The National Marine Fisheries Service indicated that the five species of whales and five species of marine turtles may be present. The majority of the species listed by the Fish and Wildlife Service are restricted to upland areas. Exemptions include the Florida manatee which only occasionally wanders into this area of the Gulf and the American alligator which prefers swamps, lakes, sloughs, and sluggish streams along the mainland. Whales are primarily restricted to open gulf waters and therefore would not be impacted by implementation of the recommended plan. Sea turtles may occur within the Mississippi Sound and

may nest on the gulf beaches of the barrier islands. Of prime importance is the Kemp's (Atlantic) ridley turtle which is considered to be the most endangered of the species listed for this area. This turtle is known from the Mississippi Sound and is typically associated with shallow vegetated habitats. The recommended plan does not require dredging or disposal near any shallow vegetated habitats therefore no impacts to this species are expected to occur. The other species occur less frequently within the sound and therefore would not be impacted by the proposed action. Concurrence with this finding was requested from the U.S. Fish and Wildlife Service (FWS) and the National Marine Fisheries Service on November 1, 1988. The FWS, in the final Fish and Wildlife Coordination Act Report dated November 10, 1988, indicated that no impacts would occur to endangered species but that coordination should continue since additional species may be listed in the future. By letter dated May 26, 1989, the NMFS concurred with the determination that species under their purview would not be adversely affected by the proposed action (See Section 8, Appendix D). The NMFS expressed concern, however, that the use of thin layer disposal on a broad scale may result in major disruptions of sea turtle habitat, and that the recovery of endangered and threatened sea turtles might be jeopardized. Much of the information to be collected during the demonstration program will be appropriate to providing evidence relative to the level of impacts which may occur to these species with the use of this technique.

(7) Other wildlife. No significant effects.

(8) Actions to minimize impact. Dredged material will be placed in the proposed open water disposal sites in a thin layer of 12 inches or less. The use of currently approved open water disposal areas and the restriction of the placement of new work dredged material to three separate spatial and temporal locations would minimize impacts from the demonstration program. Based on the results of this program, recommendations may be made which would further reduce impacts to the aquatic ecosystem.

f. **Proposed Disposal Site Determinations.**

(1) Mixing zone determination. The State of Mississippi determines mixing zones on a case-by-case basis. For similar disposal activities, the State has established a mixing zone of 750 feet. Turbidity increases of 50 JTU's above background levels beyond a 750-foot mixing zone are not projected to occur during either the disposal of maintenance dredged material or during the new work demonstration program. Historical use of the open water sites during maintenance of the Gulfport Channel has been conducted in accordance with the established mixing zone. It is believed that disposal of new work material during the demonstration program will also adhere to this mixing zone since the disposal operation is restricted to a 10-day period. Additional data, however, will be gathered during the demonstration program which will monitor the levels of turbidity around the discharge point and the extent of the turbidity plume.

(2) Determination of compliance with applicable water quality standards. This area of the Mississippi Sound is classified for recreational use and shellfish harvest. The disposal operation would

not alter constituent concentrations established for this use, and would not violate other State Water Quality Standards. Historic use of these areas for the placement of maintenance dredged materials from the Gulfport Harbor navigation project has not resulted in violation of water quality standards. The disposal of new work dredged material during the demonstration program is projected to meet appropriate criteria since the disposal operations are limited to three separate 10-day periods. During each of these periods, early spring, mid-summer, and fall a different location within Mississippi Sound will be utilized. Although violations are not projected to occur, a significant portion of the demonstration program is designed to monitor impacts to water quality, including suspended solids, turbidity, and resuspension of dredged material.

(3) Potential effects on human use characteristic. The disposal operation would not adversely affect any of the human use characteristics of the area.

(a) Municipal and private water supply. No significant effects.

(b) Recreational and commercial fisheries. Some impacts to fish and wildlife resources could occur depending upon timing of dredged material placement in open water, however, based on existing information, these are not considered to be significant. Information relative to these resources will be gained during the demonstration program.

(c) Water-related recreation. Use of the immediate area of dredging and disposal will be restricted, however, this restriction will be temporary and no significant effects would result.

(d) Aesthetics. Dredging in late fall to early winter would miss the peak recreational season however it may not be possible to schedule the disposal activities during this time due to weather and the time required to complete the activities would be longer than this period. The presence of the dredge, dredge pipe, and associated water and land based equipment would be evident and would temporarily degrade aesthetic qualities of the area.

(e) Parks, national and historic monuments, national seashores, wilderness areas, research sites, and similar preserves. No impact.

g. **Determination of Cumulative Effects on the Aquatic Ecosystem.** The data and information presented suggest that the utilization of the proposed disposal sites would have no significant cumulative adverse effects on the aquatic ecosystem. The disposal of maintenance dredged material is proposed for open water sites west of the channel, new work dredged material east of the channel. In addition, the disposal of new work material is restricted to three separate 10-day events during the year long construction period. The results of the demonstration program will be utilized to make recommendations relative to future disposal operations and the need for mitigative activities.

h. **Determination of Secondary Effects on the Aquatic Ecosystem.** The data and information presented suggested that secondary effects on the aquatic ecosystem from the proposed open water disposal would be minimal. As discussed above the results of the demonstration program will be utilized in determining other impacts on the aquatic system.

III. FINDINGS OF COMPLIANCE OR NON-COMPLIANCE WITH THE RESTRICTIONS ON DISCHARGE.

a. No significant adaptations of the guidelines were made relative to this evaluation.

b. A number of alternatives were considered during the planning process including: (1) No action and;

(2) Use ocean dumping.

c. The planned disposal of dredged materials would not violate any applicable State water quality standards.

d. The disposal operation would not violate the Toxic Effluent Standards of Section 307 of the Clean Water Act.

e. As required by the Coastal Zone Management Act, the proposed action is consistent with the Mississippi Coastal Program (MCP) to the maximum extent practicable.

f. Use of the selected disposal sites would not harm any endangered species or their critical habitat.

g. The disposal operation would not violate the Specified Protection Measures for Marine Sanctuaries Designated by the Marine Protection, Research, and Sanctuaries Act of 1972.

h. The proposed disposal of fill materials would not result in significant adverse effects on human health and welfare, including municipal and private water supplies, recreation and commercial fishing, plankton, fish, shellfish, wildlife, and special aquatic sites. The life states of aquatic life and other wildlife would not be adversely affected. Significant adverse effects on aquatic ecosystem diversity, productivity and stability, and recreational, aesthetic and economic values would not occur.

i. Appropriate steps to minimize potential adverse impacts of the discharge on aquatic systems have been included in this evaluation.

j. As required in Section 4(n) of the Water Resources Development Act of 1988, a demonstration program for the purpose of evaluating the costs and benefits of thin layer disposal in the Mississippi Sound of dredged material has been implemented. The required Study Team has been established including representatives of Federal and State resource agencies and the local sponsor. The demonstration program and a discussion of the coordination aspects associated with the development of the plan are

included in Appendix D-9. Detailed scopes of study are currently being developed in conjunction with the Study Team. These documents will be included in Appendix D-9 as they are finalized.

k. On the basis of the guidelines, the proposed sites for the discharge of fill materials are specified as complying with the requirements of these guidelines with the inclusion of appropriate and practical conditions to minimize pollution or adverse effects to the aquatic ecosystem.

DATE: 14 Mar 90

LARRY S. BONINE
Colonel, Corps of Engineers
District Engineer

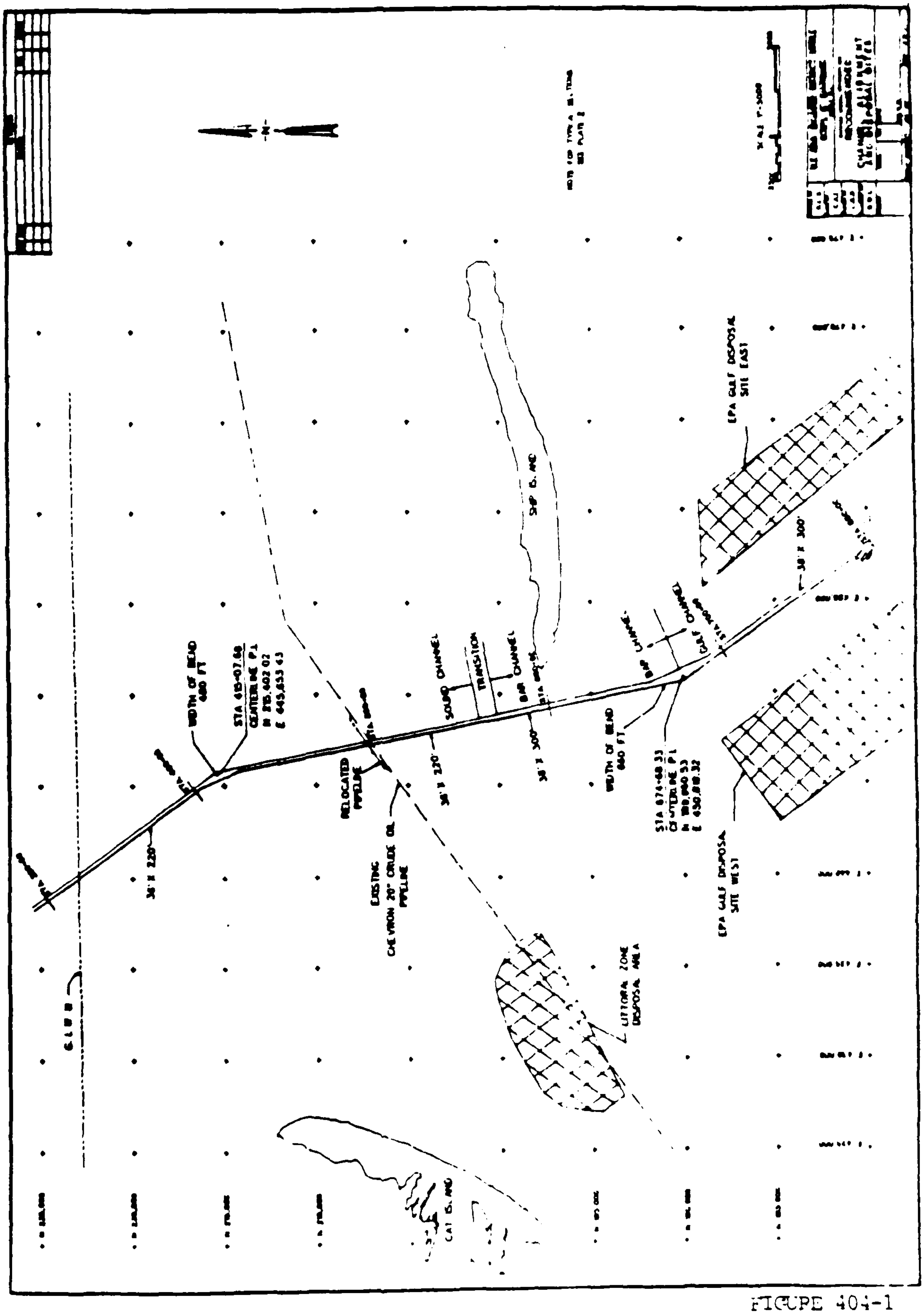

EPA GULF DISPOSAL SITE EAST
SHIP IS. AND
SOUND CHANNEL
TRANSITION
BAR CHANNEL
GULF CHANNEL
WIDTH OF BEND 660 FT
RELOCATED PIPELINE
EXISTING CHEVRON 20" CRUDE OIL PIPELINE
EPA GULF DISPOSAL SITE WEST
LITTORAL ZONE DISPOSAL AREA
CAT IS. AND

FIGURE 404-1

SECTION D-7

SECTION 103

OCEAN DISPOSAL EVALUATION REPORT

SECTION 103
OCEAN DISPOSAL EVALUATION REPORT
GULFPORT HARBOR, MISSISSIPPI

I. **Description of Proposed Action.** The Water Resources Development of 1986 (P.L. 99-662) authorized for construction: "The Project for navigation, Gulfport Harbor, Mississippi: Report of the Chief of Engineers, House Document Numbered 96-18, at a total cost of $81,700,000, with an estimated first Federal cost of $61,100,000 and an estimated first non-Federal cost of $20,600,000; except that, for reasons of environmental quality, dredged material from such project shall be disposed of in open water in the Gulf of Mexico in accordance with all provisions of Federal law. For the purpose of economic evaluation of this project the benefits from such open water disposal shall be deemed to be at least equal to the costs of such disposal." The General Design Memorandum and Final Environmental Impact Statement, dated June 1989, recommend the disposal of approximately 11 million cubic yards of new work material dredged during the construction of the turning basin, Mississippi Sound and Gulf Entrance channels in the EPA (Environmental Protection Agency) designated Gulf disposal areas at Gulfport, Mississippi. In addition, approximately 400,000 cubic yards of maintenance material dredged from the Gulf Entrance channel would be placed in these sites annually. This maintenance quantity is approximately 75,000 cubic yards greater than what is currently placed in the site annually.

II. **Description of the Disposal Area.** In 1987, the EPA designated two Ocean Dredged Material Disposal Sites (ODMDS) at Gulfport. These sites are defined by the following coordinates:

Eastern Site		Western Site	
30o 11' 10" N	88° 58' 24" W	30° 12' 00" N	89° 00' 30" W
30° 11' 12" N	88° 57' 30" W	30° 12' 00" N	89° 00' 30" W
30° 07' 12" N	88° 54' 24" W	30° 11' 00" N	89° 00' 00" W
30° 07' 24" N	88° 54' 48" W	30° 07' 00" N	88° 56' 30" W
		30° 06' 36" N	88° 57' 00" W
		30° 10' 30" N	89° 00' 36" W

The eastern site is approximately 0.7 nautical miles (nmi) south of Ship Island and contains an area of approximately 2.47 nmi^2 in water depths averaging 27 feet. The western site is approximately 1.2 nmi southwest of Ship Island and contains an area of approximately 5.2 nmi^2 in water depths averaging 24 feet (Figure 103-1). The sites have been used historically for maintenance material dredged from the Ship Island Pass and Gulf Entrance channels. These ODMDS are described in detail in "Final Environmental Impact Statement for the Pensacola, FL, Mobile, AL, and Gulfport, MS Dredged Material Disposal Site Designation (EPA, 1986).

III. **Description of Dredged Material.** Soils in the turning basin are predominately firm clays, clay-sands, and sands. The predominant soils encountered in the Mississippi Sound channel segment are plastic clays, poorly graded sands, and silty sands. In the Gulf Entrance channel, the soils consist almost entirely of soft gray plastic clay.

IV. **Environmental Testing Results.** Toxicity and bioaccumulation studies were performed on sediment samples taken from the channel (EPA, 1988). Results of these studies indicated that the toxicity of the sediments tested was minimal. Survival in 100% suspended solid phase (SSP) of the sediments was greater than 80% and not significantly different from SSP prepared with reference or control sediments. Exposure to the sediments for 10 days had little observable adverse effect on oysters (Crassostrea virginica) or pink shrimp (Penaeus duorarum). Survival of oysters was 96% in the reference sediment and 90% in sediments from the project area. Shrimp survival was 100% in the reference sediment and $\geq$ 94% in site sediments. Survival of lugworms (Arenicola cristata) exposed to sediments from sites 2 and 3 was not significantly different to survival in reference sediments. Survival of lugworms exposed to sediment from the northernmost sampling location (Site 1), however, was significantly different from survival in reference sediments.

Chemical analyses performed on sediments and on tissues from the organisms utilized in the toxicity tests revealed no residues of pesticides or PCBs in either the sediments of the tissues before or after exposure. Residues of several heavy metals were detected in sediments and in tissues of organisms before and after exposure. Using analysis of variance at the 0.05 probability level, concentrations of metals in oysters and lugworms exposed to project sediments were not significantly greater than concentrations of metals in animals exposed to a reference sediment. Although statistically significant differences were determined for selenium and zinc in shrimp, appropriate consideration should be given to the magnitude of these numbers. (For more detail refer to Sections D-3 and D-4 of this appendix)

V. **Need for Ocean Disposal.** Gulfport Harbor is a land filled harbor area on the southern shore of Harrison County in western Mississippi. The navigation channel extends from the harbor area southward across Mississippi Sound to deep water in the Gulf of Mexico. The shoreline in the vicinity of Gulfport Harbor consists of a manmade beach beyond a concrete seawall. Land use in southern Harrison County is residential, commercial and military.

Due to the location of the navigation facility and the land use patterns in the area, the only practicable alternative to ocean disposal is open water disposal in Mississippi Sound. A number of open water disposal options, i.e. island creation, thin-layer disposal, beach nourishment, have been considered. These alternatives and the rationale for their elimination is discussed in detail in the "Revised Draft Environmental Impact Statement, Gulfport Harbor, Harrison County, Mississippi, Navigation Improvements" (COE, 1988).

VI. **Environmental Impacts of the Proposed Action.**

a. Esthetics. Short term increases in turbidity will be associated with the disposal of fine grained material in Gulf waters. These impacts are not considered significant due to the distance of the ODMDS from recreation resources and the highly variable natural turbidity of the area.

b. Recreation Resources. Due to the distance from beaches or other recreational resources, the proposed use of the ODMDS will not result in

unacceptable impacts.

c. Commercial Marine Resources. The Gulfport ODMDS lies within a productive fishing region and is utilized for spawning, feeding, and breeding by migrating finfish and shellfish. However, the Gulfport ODMDS represents only a small portion of the nearshore fishing grounds in the northern Gulf of Mexico. The proposed use of the ODMDS should have a negligible impact on commercial resources.

d. Navigation. The Gulfport ODMDS's lie outside the designated navigation channels and safety fairways. No impact to navigation would occur.

e. Mineral Resources. No impact. Active lease areas in the Gulf of Mexico are located southeast of the project area in areas greater than 3 miles from the barrier island shorelines.

f. Water Quality. Short-term and localized impacts to turbidity, dissolved oxygen, and biological oxygen demand are expected to occur during the disposal activities. Circulation patterns within the Gulf and resulting dispersion will significantly minimize these impacts.

g. Historical and Archeological Resources. No impact.

h. Endangered Species. Although a number of whales and sea turtles move through the vicinity of the ODMDS, the disposal of dredged material would have no impact on their use of the area.

VII. **Determinations and Findings.**

I have reviewed the project files, Environmental Impact Statement and the Ocean Disposal Evaluation Report. The proposed ocean disposal will present:

(a) No unacceptable adverse effects on human health and no significant damage to the resources of the marine environment;

(b) No unacceptable adverse effect on the marine ecosystem;

(c) No unacceptable adverse persistent or permanent effects to the dumping of the particular volumes or concentrations of these materials; and

(d) No unacceptable adverse effect on the ocean for other uses as a result of direct environmental impact.

DATE: 5 Jul 89

for: Larry S. Bonine LTC, Deputy
Colonel, Corps of Engineers
District Engineer

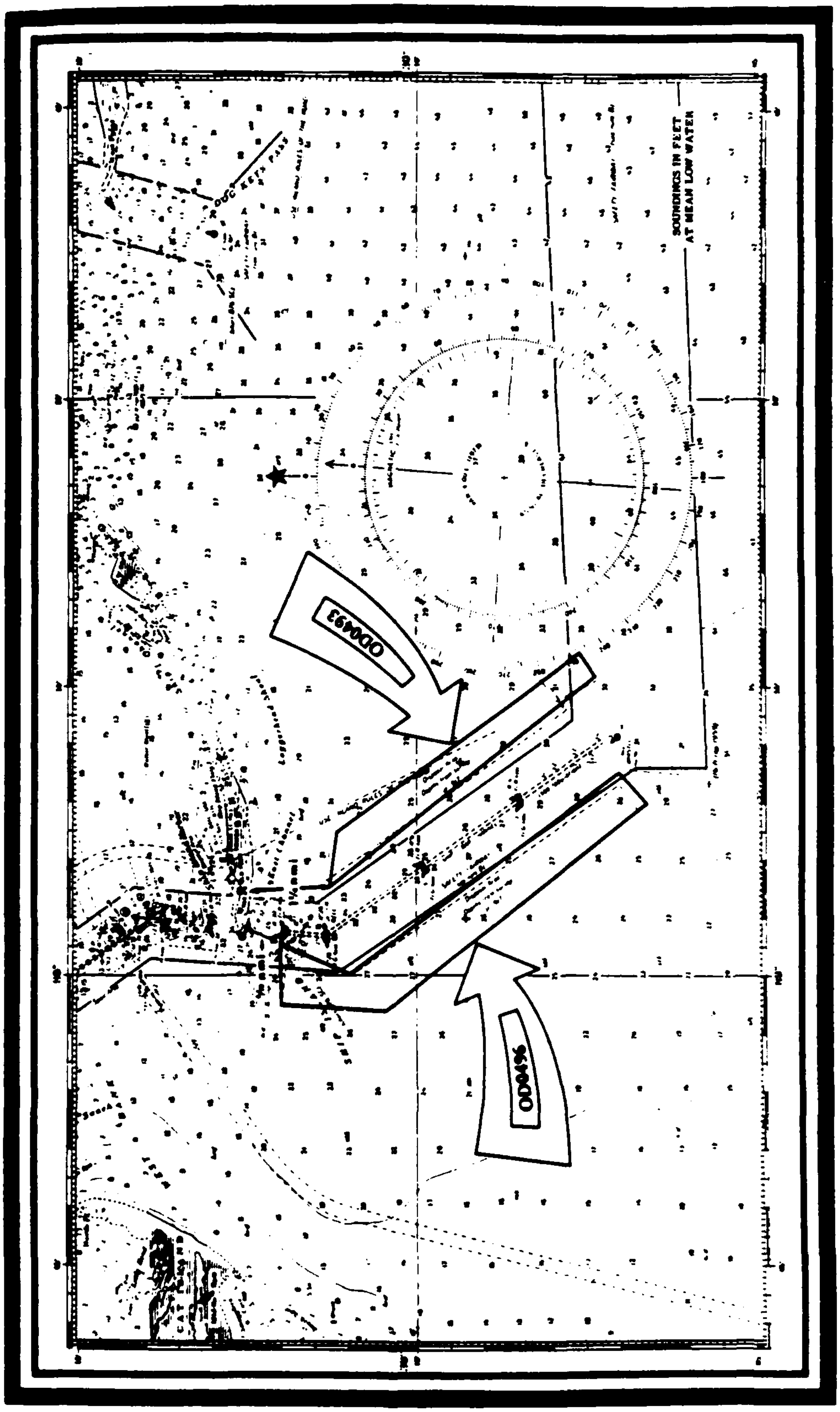


Figure 103-1

OD0493

Boundary Coordinates .... 30°11'18"N., 88°58'24"W.
30°11'12"N., 88°57'30"W.
30°07'36"N., 88°54'24"W.
30°07'24"N., 88°54'48"W.

Center Coordinates .... 30°09'22"N., 88°56'16"W.

OD0496

Boundary Coordinates .... 30°12'00"N., 89°00'30"W.
30°12'00"N., 88°59'30"W.
30°11'00"N., 89°00'00"W.
30°07'00"N., 88°56'30"W.
30°06'36"N., 88°57'00"W.
30°10'30"N., 89°00'36"W.

Center Coordinates .... 30°09'16"N., 88°59'00"W.

SECTION D-8

ENDANGERED SPECIES LETTERS

September 30, 1988

Coastal Environment Section

Mr. Larry Goldman
U. S. Fish and Wildlife Service
Post Office Drawer 1190
Daphne, Alabama 36526

Dear Mr. Goldman:

The U. S. Army Corps of Engineers, Mobile District, is preparing a revised Draft Environmental Impact Statement for channel improvements at Gulfport Harbor, Mississippi. A map of the project area is enclosed.

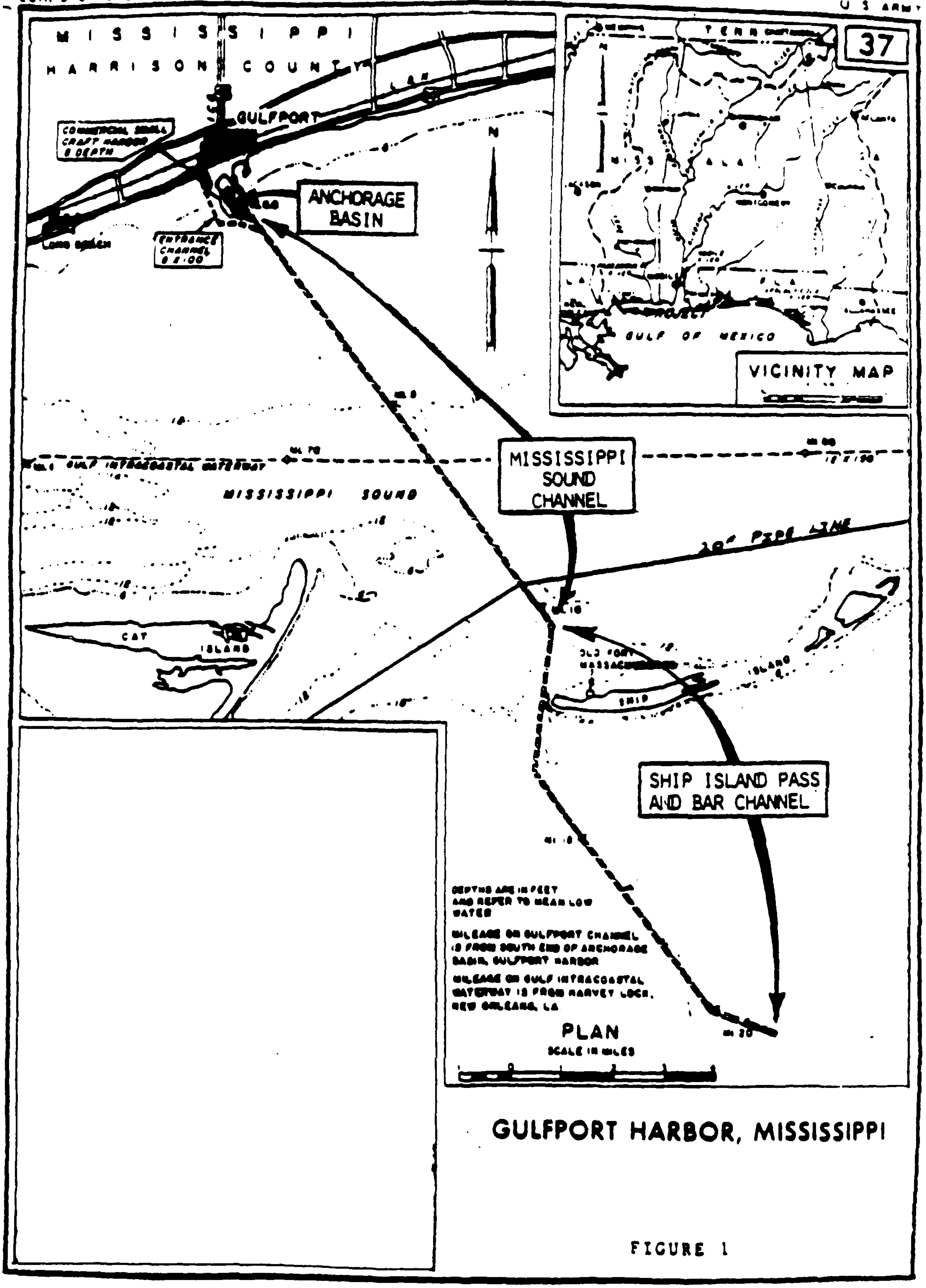
As required by Section 7 of the Endangered Species Act, we are requesting a list of endangered and threatened species that may occur in this area.

Please direct any questions on this matter to Dr. Susan Ivester Rees at (205) 690-2724.

Sincerely,

Hugh A. McClellan
Chief, Environment and Resources Branch

Enclosure



GULFPORT HARBOR, MISSISSIPPI

FIGURE 1

November 1, 1988

Coastal Environment Section

Mr. Larry Goldman
U.S. Department of the Interior
Fish and Wildlife Service
Post Office Drawer 1190
Daphne, Alabama 36526

Dear Mr. Goldman:

The enclosed revised Draft Environmental Impact Statement discusses endangered and/or threatened species which may occur in the project area, as well as possible impacts associated with implementation of the recommended plan or alternatives to this plan. The revised DEIS constitutes our biological assessment as required under Section 7 of the Endangered Species Act of 1973, as amended.

We have concluded that none of the proposed alternative improvements of the Gulfport Harbor channel would significantly affect the continued existance of any endangered or threatened species.

We appreciate your assistance in helping us protect the nation's resources.

Hugh A. McClellan
Chief, Environment and Resources
Branch

Enclosure

September 30, 1988

Coastal Environment Section

Mr. Charles A. Oravetz
National Marine Fisheries Service
9450 Koger Boulevard
Duvall Building
St. Petersburg, Florida 33702

Dear Mr. Oravetz:

As Dr. Susan Rees of my staff discussed with you recently, the U. S. Army Corps of Engineers, Mobile District, is preparing a revised Draft Environmental Impact Statement for channel improvements at Gulfport Harbor, Mississippi. A map of the project area is enclosed.

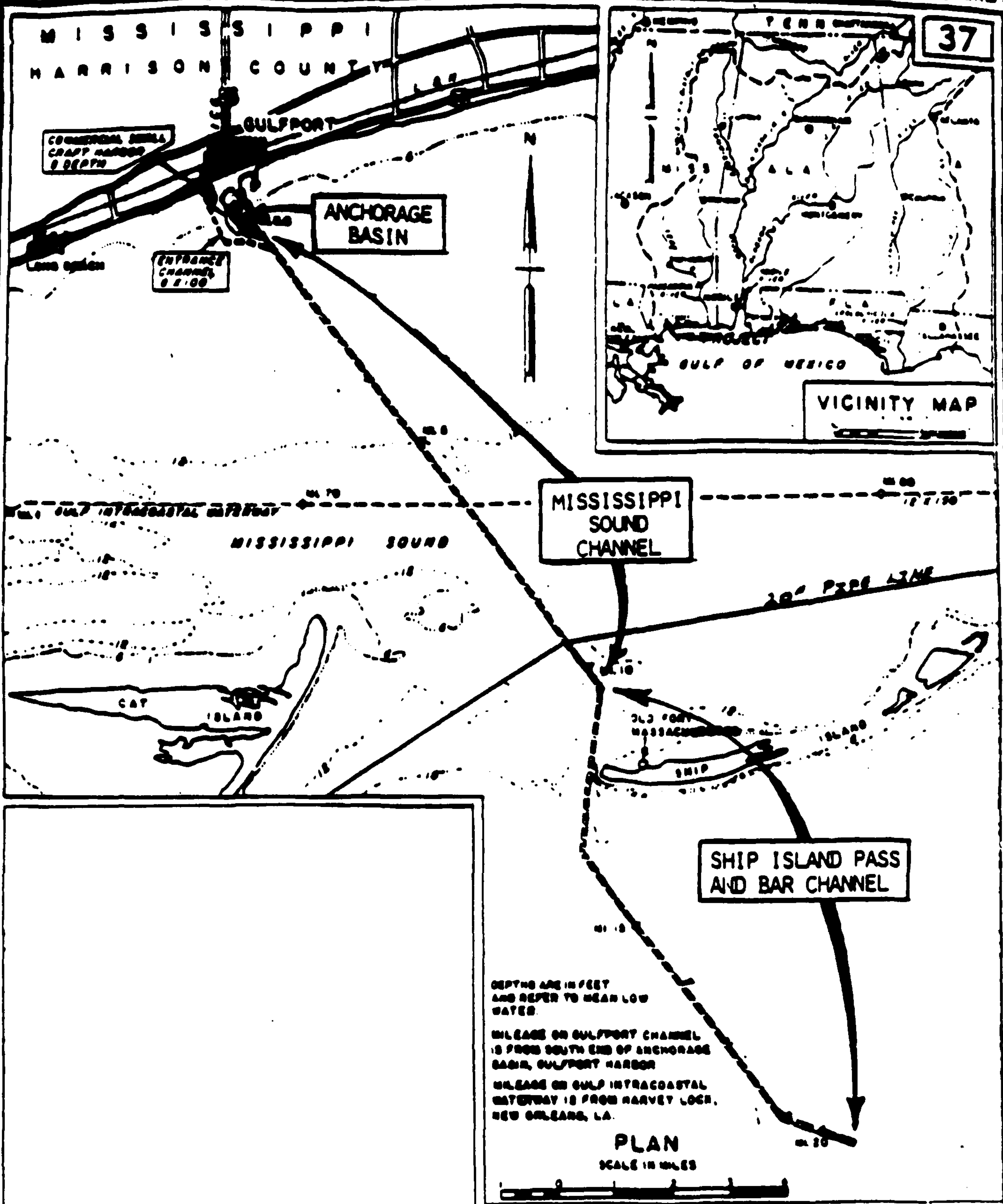
As required by Section 7 of the Endangered Species Act, we are requesting a list of endangered and threatened species that may occur in this area.

Please direct any questions on this matter to Dr. Rees at (205) 690-2724.

Sincerely,

Hugh A. McClellan
Chief, Environment and Resources Branch

Enclosure



GULFPORT HARBOR, MISSISSIPPI

FIGURE 1

UNITED STATES DEPARTMENT OF COMML...
National Oceanic and Atmospheric Administ...
NATIONAL MARINE FISHERIES SERVICE
Southeast Regional Office
9450 Koger Boulevard
St. Petersburg, FL 33702

October 4, 1988 F/SER23:TAH:td

Mr. Hugh A. McClellan
Chief, Environment & Resources
Branch
Department of the Army
Mobile District, COE
Post Office Box 2288
Mobile, Alabama 36628-0001

Dear Mr. McClellan:

This responds to your letter of September 30, 1988, requesting a list of endangered and threatened species which may occur in the Gulfport Harbor, Mississippi. We understand that you are preparing a Draft Environmental Impact Statement (DEIS) addressing impacts associated with improvements for the Gulfport Harbor channel.

The enclosed list provides the threatened and endangered species under the National Marine Fisheries Service jurisdiction that may be present in the project area. If you have any questions, please contact Dr. Terry Henwood, Fishery Biologist at FTS 826-3366.

Sincerely yours,

Charles A. Oravetz

Charles A. Oravetz, Chief
Protected Species Management
Branch

Enclosure

cc: F/PR2
F/SER1

ENDANGERED AND THREATENED SPECIES AND CRITICAL HABITATS UNDER NMFS JURISDICTION

Mississippi

Listed Species	Scientific Name	Status	Date Listed
finback whale	Balaenoptera physalus	E	12/02/70
humpback whale	Megaptera novaeangliae	E	12/02/70
right whale	Eubaleana glacialis	E	12/02/70
sei whale	Balaenoptera borealis	E	12/02/70
sperm whale	Physeter catodon	E	12/02/70
green sea turtle	Chelonia mydas	Th	07/28/78
hawksbill sea turtle	Eretmochelys imbricata	E	06/02/70
Kemp's (Atlantic) ridley sea turtle	Lepidochelys kempi	E	12/02/70
leatherback sea turtle	Dermochelys coriacea	E	06/02/70
loggerhead sea turtle	Caretta caretta	Th	07/28/78

SPECIES PROPOSED FOR LISTING
None

LISTED CRITICAL HABITAT
None

PROPOSED CRITICAL HABITAT
None

November 1, 1988

Coastal Environment Section

Dr. Terry Henwood
Protected Species Management Branch
National Marine Fisheries Service
9450 Koger Boulevard
St. Petersburg, Florida 33702

Dear Dr. Henwood:

Reference is made to your letter of September 30, 1988, regarding channel improvements for Gulfport Harbor, Mississippi. The enclosed revised Draft Environmental Impact Statement discusses endangered and/or threatened species which may occur in the project area, as well as possible impacts associated with implementation of the recommended plan or alternatives to this plan. The revised DEIS constitutes our biological assessment as required under Section 7 of the Endangered Species Act of 1973, as amended.

We have concluded that none of the proposed alternative improvements of the Gulfport Harbor channel would significantly affect the continued existence of any endangered or threatened species.

We appreciate your assistance in helping us protect the nation's resources.

Hugh A. McClellan
Chief, Environment and Resources
Branch

Enclosure

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Southeast Regional Office
9450 Koger Boulevard
St. Petersburg, FL 33702

May 26. 1989 F/SER23:TAH:td

Mr. Hugh A. McClellan
Chief, Environment and Resources Branch
Mobile District COE
P.O. Box 2288
Mobile, Alabama 36628-0001

Dear Mr. McClellan:

This responds to your November 1, 1988, letter regarding channel improvements for Gulfport Harbor, Mississippi. A Draft Environmental Impact Statement (DEIS) was transmitted pursuant to Section 7 of the Endangered Species Act (ESA). I apologize for our belated response, but your letter was misplaced and we were only recently advised that this consultation was pending.

We have reviewed the DEIS and concur with your determination that populations of endangered/threatened species under our purview would not be adversely affected b" the proposed action.

Although we have agreed with your determination that listed species are unlikely to be negatively impacted by this particular action, we are disturbed with the potential ramifications of the thin-layer disposal experiment. Our foremost concern is that, if shown to be economically advantageous and if no adverse impacts are readily evident, this methodology might be adopted for other channel dredging in the southeast. It is our belief that widespread use of thin-layer disposal could result in major disruptions of sea turtle habitat, and that the recovery of endangered and threatened sea turtles might be jeopardized. Therefore, you are advised that we will need additional information on the effects of this methodology before concurrence with future thin-layer disposal operations.

The U.S. Army Corps of Engineers (COE) plan to fund a major research effort to evaluate the impacts of thin-layer disposal. We support this effort, and consider such research to be essential. We have received a draft of your study plan describing proposed sampling methodology, but this plan says nothing about what hypotheses are being tested. Studies describing what organisms are present before and after spreading a foot of dredged materials over large areas of bottom tell us nothing about the total impact of this action to the ecosystem. I think we already know what species of benthic organisms are present, what will likely happen to these organisms if covered by a foot of dredged material, what changes in water quality may occur, what vertebrate species will be displaced, and that recolonization will begin soon after dumping ceases. What we don't know is what happens to displaced

individuals, what impact this displacement or reduction of water quality may have on the overall productivity of the sound, whether resources become limiting through competition when large areas of the bottom are rendered uninhabitable, what species are particularly vulnerable to such changes, whether concentration of organisms outside the disposal area makes them more vulnerable to fishing activity or predation, etc., etc. In our opinion, the present study design will not provide the information that we need, it will simply recapitulate the obvious.

If thin-layer disposal methodology is to be considered for use in other locations, the COE must demonstrate that it is no more destructive than the present use of offshore disposal sites. We strongly recommend that you give serious consideration to the study design, and take whatever steps are necessary to insure that the results of the study will answer the appropriate questions and have some statistical validity.

From a protected species standpoint, our major concern is whether this methodology negatively affects listed species or their critical habitat. If it does, we oppose this method of disposal and will request offshore dumping in EPA designated sites for future dredging projects. If your study is inconclusive or does not provide the needed information to adequately assess impacts to listed species, we are required under the ESA to assume the worst and issue our biological opinion accordingly. Therefore, upon completion of this study and before considering any future thin-layer disposal operations, we expect "strong evidence" that endangered and threatened sea turtles are not being negatively impacted by this activity. As you know, the burden of proof that these activities are <u>not</u> impacting listed species, lies with the COE.

This concludes consultation responsibilities under Section 7 of the ESA. However, consultation should be reinitiated if new information reveals impacts of the identified activity that may affect listed species or their critical habitat, a new species is listed, the identified activity is subsequently modified or critical habitat determined that may be affected by the proposed activity.

If you have any questions, please contact me at (813) 893-3366.

Sincerely yours,

Terry Henwood

Tyrrell A. Henwood, Ph.D.
Protected Species Management
Branch

cc: F/PR2
F/SER1 - Andy Mager/Ed Keppner
F/SEC9 - David Colby

SECTION D-9

GULFPORT HARBOR, MISSISSIPPI

THIN LAYER DEMONSTRATION PROGRAM

GULFPORT HARBOR, MISSISSIPPI NAVIGATION PROJECT

THIN LAYER DEMONSTRATION PROGRAM

Background: The Water Resources Development Act (WRDA) of 1988 directed the Secretary to "carry out a demonstration program for the purpose of evaluating the costs and benefits of thin layer disposal in the Mississippi Sound of dredged material from construction of harbor improvements, including any operation and maintenance materials that may be removed during construction, and for determining whether or not there are unacceptable adverse effects from such disposal -

(i) on human health or welfare, including but not limited to plankton, fish, shellfish, wildlife, shorelines, and beaches:

(ii) on marine life (including the transfer, concentration, and dispersal of pollutants or their byproducts through biological, physical, and chemical processes), changes in marine ecosystem diversity, productivity and stability, and species and community population changes;

(iii) on esthetic, recreation, and economic values; and

(iv) on alternative uses of oceans, such as mineral exploitation and scientific study".

In addition, the results of these studies are to be utilized to determine "the persistence and permanence of any such adverse effects and methods of mitigating any such adverse effects".

Study Team: Pursuant to the WRDA of 1988, the Secretary has established a study team composed of the following individuals:

Mr. Nathaniel D. McClure, IV, Mobile District U. S. Army Corps of Engineers, Chairman

Dr. Susan Ivester Rees, Mobile District U. S. Army Corps of Engineers, Demonstration Program Manager

Mr. Douglas R. Nester, Mobile District U. S. Army Corps of Engineers

Mr. C. T. Green, Mississippi State Port Authority (Local Sponsor)

Mr. Larry Lewis, Mississippi Department Wildlife Conservation, Bureau of Marine Resources

Mr. James Morris, Mississippi Department of Natural Resources, Bureau of Pollution Control

Mr. David Nixon, National Marine Fisheries Service

Dr. Donald Hoss, National Marine Fisheries Service, Beaufort Laboratory

Mr. Larry Goldman, represented by Mr. Tom Thornhill, U. S. Fish and Wildlife Service

Dr. William Kruczynski, Environmental Protection Agency, Region IV

Dr. Gerald Miller, Environmental Protection Agency, Region IV

Coordination Activities: A series of meetings of the study team were held beginning in January 1989. As a result of these meetings the following items relative to the demonstration program were resolved.

(1) The duration of the program will be three years: one year pre-disposal baseline monitoring and two years post disposal monitoring. In addition, selected resources will be investigated during actual disposal activities.

(2) Pre-disposal monitoring will be completed prior to initiation of dredging the Mississippi Sound portion of the project.

(3) Three separate disposal events, one each in early spring, mid-summer, and fall, will be investigated. Each event will last approximately 10 days and will result the placement of approximately 1 million cubic yards of new work material and maintenance material, respectively.

(4) The impacts of new work (construction) and maintenance materials will be investigated separately.

(5) Areas to be utilized during the study will be restricted to those that are currently specified and certified for the maintenance of the existing Gulfport Harbor Project.

(6) The depth of the thin layer disposal will be restricted to no more than 12 inches over the designated disposal areas.

(7) Resources to be investigated include:
water quality
infauna
fishery
bathymetry.

(8) That traditional fish surveys measuring standing crops would be unlikely to provide useful information, because of the inherent variability of standing crop measurements among replicate samples and among years, and because tidal circulation would be expected to lead to rapid advection of planktonic and weakly swimming larvae, rapidly replenishing waters overlying the disposal site, and therefore limiting correlation of standing crops with the disposal event.

(9) That a combination of laboratory and controlled field studies will more appropriately provide information for assessing the consequences of thin layer disposal on fisheries resources.

Although many of the general aspects of the demonstration project have been defined, additional coordination efforts among study team members and members of the local scientific community are required to refine the specifics of the plan and prepare the Scopes of Work for the required studies. This is especially true of the research relative to the effects of thin layer disposal on fishery resources. A detailed plan for these efforts will be prepared by 13 April 1990 as a coordinated effort between the National Marine Fishery Service, Beaufort Laboratory and the Mobile District (Joint

NMFS/CE Memo dated 21-22 February 1990). Some modification of the already agreed upon aspects of the program may be required to fulfill the needs of the fishery studies.

A meeting of the study team will be convened in late April 1990 to discuss any required modifications and to begin preparation of the detailed Scopes of Work.

Scope of the Demonstration Project: The Demonstration Project is being designed to provide information which will be used to determined the impacts associated with the thin layer placement of new work and maintenance dredged material on estuarine resources. This information may also be utilized to design modifications to thin layer placement to reduce impacts or to design actions which could be taken to mitigate for unacceptable impacts. In determining what information was necessary a number of questions were posed concerning thin layer placement including:

1. What is the physical impact of thin layer disposal on larval fishes,
2. What is the biological impact of thin layer disposal on fishery resources,
3. What is the thickness of the layer of dredged material placed on the bottom during the operation,
4. What changes in water quality occur as a result of the disposal operation and how long is the period of recovery to ambient conditions,
5. What has been the impact of historic thin layer disposal of maintenance material on benthic communities,
6. What is the level of impact and how extensive is the period of recovery of benthic communities following thin layer disposal of new work material.

Studies which are being proposed include both field and laboratory studies. Field studies are primarily directed toward effects on water quality, bathymetry, and infaunal resources. Laboratory studies are directed primarily toward effects on fishery resources, however some controlled field studies are envisioned. Although these studies differ significantly in approach, the overall program is interdisciplinary in nature.

I. INFAUNAL STUDIES

a. Predisposal Studies

Seven areas within Mississippi Sound, including the location of the 1986/87 thin layer disposal test will be utilized for infaunal studies. Macroinfauna sampling will be on a monthly basis whereas meioinfauna sampling will be on a quarterly

basis. At the end of the predisposal studies for infauna, analyses will be undertaken to determine the level of difference between control areas, areas historically and recently disposed upon, and areas historically but not recently disposed upon. It is the intent of the Study Team to utilize this information to determine the long-term impacts of thin layer disposal of maintenance material on benthic infaunal resources. If the results of these baseline surveys indicate that the level of impacts due to historic maintenance disposal are not unacceptable, then no further studies of maintenance disposal impacts on these resources will be undertaken. Members of the Study Team believe this to be a reasonable approach since existing information on these resources indicates that historic disposal actions has not caused deterioration of benthic resources in this area.

At each area 10 replicate box cores, 30 cm x 30 cm to a depth of 15 cm (approximately $0.0652m^2$ sample), will be taken for macrobenthic analyses. A 2.5 cm diameter core subsample will be taken from each box core for sediment grain size analysis. Subsamples for meiofaunal analyses will be taken from 3 of the replicate box core samples on a quarterly basis. The total number of baseline samples are 840 for macrofaunal and grain size analyses and 84 for meiofauna as calculated below:

Macrofauna: 7 areas x 10 reps/area x 12 days = 840
Grain Size: 7 areas x 1 subsample/rep x 10 reps/area x 12 days = 840
Meiofauna: 7 areas x 1 subsample/rep x 3 reps x 4 days = 84

For macrofauna analysis samples will be sieved utilizing a series of stacked sieves (6.5, 3.5, 2.0, 1.0, and 0.5 mm). Identification will be to the lowest practicable level (species in most cases). Wet weight biomass measurements will be required for each major taxonomic group (Annelida, Arthropoda, Echinodermata, Gastropoda, Pelecypoda, and Others). Individual species which comprise at least 5% of the total individuals by station, or large individuals which may significantly contribute to biomass of a major taxonomic group will be weighed and reported separately.

Meiofaunal samples will be processed through a 0.062 mm screen. Only nematodes and harpacticoid copepods will be sorted for identification. Identification of these will be at the lowest practicable level, at a minimum of family level but to genus in most instances.

Data reporting will include total number of organisms, total number of species, mean number of organisms, Shannon-Weiner diversity and Margalefs evenness index. Descriptive and

analytical statistics including cluster and factor analyses will also be required.

Sediment particle size analysis will include removal of large animals, oxidation of remaining organic material with hydrogen peroxide, and removal of soluble salts by washing with deionized water. Treated samples will be dispersed with sodium hexametaphosphate solution and transferred to a cylinder for hydrometer analysis. After the final hydrometer reading, the material will be dried, sieved at 0.5 phi intervals from -2.0 to 4.0 phi, and weighed. Data will be reported as percentages of sand, silt, and clay, mean diameter, kurtosis, sorting and other appropriate statistical parameters. This information will be utilized during the infaunal analyses to define community structure of the areas.

b. During Disposal Studies

No infaunal sampling is required during disposal.

c. After Disposal Studies

Infaunal sampling will be restricted to those areas which received new work material only unless the assumption discussed in paragraph Ia. above in not valid. Three sampling locations will be established within each treatment area. A control station will be established adjacent to each treatment area. Procedures outlined above will be followed resulting in a maximum of 2,880 macrofaunal and sediment grain size samples and 324 meiofaunal samples collected during the two year period as defined below:

Macrofauna & Grain Size: (3 treatment + 1 control) sample areas/disposal area x 3 disposal areas x 10 reps/sample area x 24 sample periods = 2880

Meiofauna: (3 treatment + 1 control) sample area/disposal area x 3 disposal area x 1 subsample/rep x 3 reps x 9 sample periods = 324

Total number of samples will be determined by the study team.

II. WATER QUALITY STUDIES

a. Predisposal Studies

Sampling will occur in each demonstration disposal area immediately before disposal (one day if possible). Samples to be taken at 12 locations within the general disposal area. Eight samples would be obtained at each station, 4 during ebb and 4 during flood. At each station

samples would be obtained at three depths, 1-foot below the surface, mid-depth, and 1-foot above the bottom. This would equate to 288 samples per disposal area.

The following parameters would be included in the water quality studies:

- Dissolved oxygen
- Fecal Coliform
- pH
- Temperature
- Salinity
- Ammonia Nitrogen
- Nitrate & Nitrite
- Total Phosphorus
- Orthophosphate
- Total Suspended Solids
- Turbidity
- Sulfates
- Chlorophyll a
- Total Organic Carbon (TOC) and/or Biochemical Oxygen Demand (BOD)
- Total Kjeldahl Nitrogen.
- Current Speed and Direction

The consensus of the study team was that no analyses relative to heavy metals, pesticides, or other organic contaminants were required.

Should the need arise to reduce the number of samples obtained for analysis, the following is suggested: The full suite of parameters would be measured at a minimum of one new work and one maintenance disposal site. At least one of these should be in the northern portion of the sound and one in the southern portion. The best mix would be a new work site and an O & M site in the southern portion of the sound and an O & M site in the northern portion of the sound. At the other areas a restricted suite of parameters would be measured. In addition, the measurement of fecal coliform levels could be restricted to the northern portion of the sound.

b. During Disposal Studies

Sampling would occur during days 7 - 10 of the disposal operation, providing for weather and/or equipment downtime. Samples would be taken at the 12 specified (fixed) stations (see above) as well as within the plume.

1. Sampling at the 'fixed stations' would include the 12 specified above plus 1 control station upstream and 2 stations down current in the fringe area. Sampling would occur 8 times a day for a 2 or 3 day period, 4 samples during ebb and 4 during flood at the 3 depths. A total of 672

samples would be obtained during each disposal operation.

2. 'Plume stations' would be sampled every 750 feet down current of the disposal until ambient conditions are reached. A minimum of 4 plume stations would be established. These areas would be sampled 8 times daily for a 2 or 3 day period. A maximum of 192 samples would be obtained during this sampling operation.

c. Post Disposal Studies

Sampling would begin at the 12 fixed stations immediately after dredging ceases. Eight samples a day will be obtained until background conditions are reached (estimated to be a 2 day period). If it takes longer than 2 days to reach background, sampling would be every other day until background was attained.

Resuspension potential of recently deposited dredged material would be investigated for a 6-month period following disposal. Total suspended solids (TSS) would be measured at a control location and 6 of the 12 fixed stations to determine the resuspension difference between natural and recently disposed upon bottoms.

III. BATHYMETRIC STUDIES

a. Predisposal Studies

Predisposal bathymetric surveys will be required in both the proposed new work and maintenance disposal areas. Each hydrographic survey will consist of the anticipated disposal area and an additional approximately one-hundred acre adjacent to the initial area. A one-hundred foot or larger vessel (draft permitting) will be used for stability along the survey lines. It is expected there will be approximately 200 line miles, with depths acquired at less than five foot intervals, with digital data provided for mapping. Equipment will be specified to obtain a $\pm$ .3-foot accuracy as suggested by NOS. Positioning equipment will also be specified. The number of sites to be surveyed will be determined by the study team.

b. During Disposal Studies

No hydrographic surveys are required during disposal.

c. After Disposal Studies

Hydrographic surveys will be required following the disposal operation to determine the thickness of the dredged material lift placed in the disposal sites.

Although the vertical profiling sediment camera system that was used in earlier studies aided in the bathymetric investigations, the decision to utilize the system in the demonstration program has not been finalized.

IV. FISHERY STUDIES

Candidate laboratory research topics on fishery resources include: (a) studies of survival and daily growth rates as a function of suspended sediment levels; (b) bioassays of survival in relation to oxygen level; and (c) investigations of the effects of turbidity on rates of feeding/predation.

Candidate field research topics may include: (a) short-term caging (enclosure) studies to compare feeding rates and diet composition on disposal and control sites and (b) short-term studies to compare rates and patterns of fish movements on disposal and control sites using sonic tags or some other fish tracking method.

Further Coordination Activities: As indicated above, additional details relating to fishery sampling are currently being developed. Once this is accomplished a detailed Scope of Work, suitable for a Request for Proposal (RFP), will be coordinated with the Study Team for their comment. The RFP will be circulated to interested parties following Corps procedures. Possible avenues for completion of the demonstration program include interagency agreements/transfers or contracts. Members of the Study Team may sit on the Source Selection Team. All contract activities will be monitored by U. S. Army Corps of Engineers Mobile District personnel. Interim and Draft reports will be furnished to the Study Team for their review and comment throughout the study period. Within 1 year after the date of completion of the demonstration program, a final report will be transmitted to Congress and the Administrator of the Environmental Protection Agency as required by the WRDA of 1988.

SUMMARY OF DISCUSSIONS OF FISH RESEARCH NEEDS FOR GULFPORT THIN-LAYER DISPOSAL PROJECT AT THE BEAUFORT LABORATORY, February 21-22, 1990.

Present Susan Rees, Doug Nester, Don Hoss, David Nixon, Scott Nichols and David Colby.

Susan Rees discussed the history of the Gulfport Demonstration Project, including the legislative history, the operational aspects, and previous thin-layer studies at Fowl River and at Gulfport. She reiterated the previous decisions made by the study team and the development of the "strawman" document.

The discussion then continued on to refine the nature and objectives of research into effects of the planned demonstration project on fisheries resources. The group proceeded to list those aspects of the disposal operation that would likely effect fisheries resources. Two general categories, suspended sediments and deposited sediments were recognized.

Suspended sediments may effect fish respiration through (1) direct interference with gill membranes, and (2) lowering of oxygen levels in the water column as a result of biological/chemical oxygen demand of the sediment. Suspended sediment may also affect feeding as the turbidity influences fish feeding/growth and larval predation. Suspended sediments may also directly influence movement rates in the local environment, as well as causing fish to deviate from normal migratory paths.

Deposited sediments will at least temporally bury benthic food resources, and perhaps larval fish and shrimp. The rapid colonization of the deposited sediment by certain opportunistic species such as Capitella may, within weeks of a disposal event, lead to temporary changes in food habits by certain fishes.

The group developed consensus on the following:

(1) That traditional fish surveys measuring standing crops would be unlikely to provide useful information, because of the inherent variability of standing crop measurements among replicate samples and among years, and because tidal circulation would be expected to lead to rapid advection of planktonic and weakly swimming larvae, rapidly replenishing waters overlying the disposal site, and therefore limiting correlation of standing crops with the disposal event.

(2) That a combination of laboratory and controlled field studies will more appropriately provide information for assessing the consequences of thin-layer disposal on fisheries resources.

(3) Candidate laboratory research topics may include:(a) studies

of survival and daily growth rates as a function of suspended sediment levels;(b) bioassays of survival in relation to oxygen level (should water quality data indicate critical levels on site);and (c) investigations of the effects of turbidity on rates of feeding/predation.

(4) Candidate field research topics may include:(a) short-term caging (enclosure) studies to compare feeding rates and diet composition on disposal and control sites and (b) short-term studies to compare rates and patterns of fish movements on disposal and control sites using sonic tags or some other fish tracking method.

(5) The research into effects of thin-layer disposal on fish and shellfish will be dependent on information from other components of the program, in particular, the concurrent studies of water quality, benthic organisms, and bathymetry.

(6) The above candidate fish/shellfish research topics are not intended to be all inclusive. A more detailed discussion of candidate topics will be developed within the next 30-45 days by NMFS/SEFC and CE, Mobile District.